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MONTHLY WEATHER REVIEW

AUGUST, 1930

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UNITED STATES DEPARTMENT OF AGRICULTURE
WEATHER BUREAU
WASHINGTON, D. C.

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CORRECTIONS

Monthly Weather Review, May, 1930, Vol. 58:

PAGE 180, section on method of arbitrary corrections:

V_a and E_a should be V_d

E_b should be V_b

PAGE 182:

Value for s, entered $\frac{h}{100\ (E)}$, should be $\frac{h}{100}\ (E)$,

Figure 2, curved (dew-point) lines should be numbered, upper to lower, 50° to 15° in 5° intervals.

Second column, second value of Y should be

$$\frac{738}{\frac{3{,}037.5}{t-5.5}-24+8}-7.$$

Last equation, second factor in first numerator, entered (,757), should be (8,757).

PAGE 183:

Fraction in first line, entered $\frac{d^2r}{2}$, should be $\frac{d^2Y}{dt^2}$.

Fraction in second line, entered $\frac{d^{2a}Y}{dt^2}$, should be $\frac{d^2Y}{dt^2}$.

PAGE 184, figure 6:

Upper diagram for Grand Junction, upper end of solid line numbered 80–40, should be 85–40.

Lower diagram for Medford, extremities of dotted line numbered 56–30, 66–30; should be 61–25 and 66–35, respectively.

PAGE 185: Last complete paragraph, seventh line; the word "cross" should be "circle."

MONTHLY WEATHER REVIEW

Editor, ALFRED J. HENRY

VOL. 58, No. 8
W. B No. 1025

AUGUST, 1930

CLOSED OCTOBER 3, 1930
ISSUED NOVEMBER 5, 1930

MEETING OF THE INTERNATIONAL GEODETIC AND GEOPHYSICAL UNION HELD IN STOCKHOLM, SWEDEN, AUGUST 15–23, 1930

By HERBERT H. KIMBALL, United States Delegate

The opening session of the International Geodetic and Geophysical Union was held at 11 a. m. of August 15, in the "Great Hall of the Concert House." An orchestra gave a musical program, and between numbers the Union was addressed by Mr. Ernst Trygger, Chairman of the Swedish National Committee and Chancellor of the University of Sweden, and by Mr. Ch. Lallemand, Chairman of the International Union.

The printed list of members contains 305 names, including invited guests, and 110 members of their families. The invited guests could take part in discussions, but had not the right to vote. Members of families were invited to the opening meeting and to all social functions.

The following is the list of members, guests, and members of families, of the delegation from the United States:

Members	Members of families
Austin, L. W.	Mrs. Austin.
Bigelow, H. B.[1]	Mrs. Bigelow.[1]
Bowie, W.	Mrs. Bowie.
Briggs, L. J.	
Fleming, J. A.	Mrs. Fleming.
Harradon, R. D.	Mrs. Harradon.
Heck, N. H.	Miss Emma Heck.
Heiland, C. A.[1]	
Keith, A.	Mrs. Keith.
Kennelly, A. E.	Mrs. Kennelly.
Kimball, H. H.	Mrs. Kimball.
Littlehales, G. W.	Littlehales, G. R.[1]
Macelwane, J. B.	
Thompson, G.	Mrs. Thompson.
Wenner, F.	Mrs. Wenner.
Willett, H. C.	
Guests	
Malkovsky, J. A.	
Rossby, C. G.	Mrs. Rossby.
Douglass, A. E.	

Sixteen delegates are listed, of whom Bigelow and Heiland were not present. There were three invited guests present. The names of 13 members of families are listed, of whom 2 were not present. The delegation therefore actually consisted of 14 delegates, 3 invited guests, and 11 members of families, or a total of 28.

Great Britain had a delegation numbering 38, and including such well-known names as Sir Napier Shaw, G. C. Simpson, Professor Turner, who suffered a cerebral hemorrhage as he was about to open the sessions of the Section of Seismology, and who never regained consciousness; Sir Gilbert Walker, Brigadier Winterbotham, Brigadier Jack, Sir Henry Lyons, Dr. F. J. W. Whipple, G. I. Taylor, Professor Chapman, Professor Dobson, Sir John Flett, Doctor Mitchell, O. R. Hinks, and others.

This was a strong delegation, but was outnumbered by the French delegation with its 45 members, and also by that from Sweden, although the last named was composed largely of invited guests.

At 3 p. m., August 15, the first plenary session of the Union was held in the Parliament House, thus setting in motion the machinery of the Fourth General Assembly.

The real work of the Union is done through its sections and commissions. Some of the latter were in session for several days before the formal convening of the Union. Among these was the Commission on Solar Radiation of the Meteorological Section, of which the writer was chairman. There were informal discussions on August 13, and the first formal meeting convened at 10 a. m., August 14, in a committee room of the Parliament House. It brought together a rather distinguished body of men, among whom were Sir Napier Shaw, Doctor Simpson, Doctor Lindholm of Davos, Doctor Götz of Arosa, Doctor Dobson of Oxford, Professor Maurain of the Geophysical Institute, University of Paris, Professor Volochine, Doctor Gorczyński, Doctor Rossby and Doctor Willett of the Massachusetts Institute of Technology, and others.

Doctor Ångström acted as secretary.

The report of the chairman was the first item considered, and very soon the question of the relation between the commission of the International Geodetic and Geophysical Union and that of the International Meteorological Committee came up. It was first discussed at some length by Sir Napier, who advocated relations much like those proposed by Professor Marvin at the last meeting of the American Geophysical Union. Others followed, and without a formal resolution it was agreed that in future the commission of the International Geodetic and Geophysical Union should function only for the purpose of considering questions relating to solar radiation that might arise at meetings of the Meteorological Section. Research problems might be assigned to special subcommissions, but questions relating to routine work, such as the standardization of instruments, and methods of measurement and publication, would be left to the Commission of the International Meteorological Committee.

The Commission was in session until 11:20 a. m., when several of the members, including the secretary, were obliged to withdraw to attend another meeting. At 2:30 p. m. a second session opened, and a third was

[1] Not present.

called for 11:30 a. m. of the 16th. A final session was held during the afternoon of August 18 to put resolutions that had been agreed upon in proper shape to present before the Meteorological Section.

There were also meetings of joint commissions, made up from members of different sections, that are deserving of mention as follows:

1. A mixed commission from the sections of Oceanography and Meteorology, to consider means of determining the extent of the polar ice caps and their effects upon weather conditions in the two hemispheres. For their conclusions see resolution XII, of the Meteorological Section. It was stated that reports from British ships show four maximum extensions of the ice sheet northwards in Antarctica, one in 1918 when there were few observations and the other three at times of sun-spot maxima. The year 1918 also had a maximum of spots.

2. A joint meeting of the sections of Magnetism and Meteorology had appointed a commission to consider the project of the polar year. Doctor La Cour had discussed this project with me at length on the train as we returned to Stockholm from our visit to Uppsala on August 20. An agreement was then reached for a meeting at 9 a. m. on the following morning. We met at 9:15, and after discussion adopted resolutions 1 to 5, which follow.

RESOLUTION 1

The subcommission appointed to report on the project of a second polar year planned by the International Meteorological Organization considers that the project is of very great importance for the advancement of physical science. It also approves the suggestion that the observations should not be confined only to Polar regions.

RESOLUTION 2

The subcommission recommends that the Union should support the steps already taken by the International Meteorological Organization to effect international cooperation, and in particular all members of the Union are requested to use their influence to obtain the active cooperation of their Governments and scientific institutions.

RESOLUTION 3

The subcommission is impressed with the desirability that all cameras, plates, and spectroscopes used in the observations of the Aurora should be of equal sensitivity; it therefore recommends that the magnetic section should vote a sum of 15,000 gold francs for the provision of instruments of the standard type.

RESOLUTION 4

The subcommission recommends that all observations should be reduced according to an agreed plan, and that the commission for the polar year should consider the best method for making the detailed observations available for study by all those interested. It also suggests that all published volumes should be put on sale, and that the various sections of the Union should subscribe for a number of copies.

RESOLUTION 5

The subcommission recommends that the Section of Meteorology and the Section of Terrestrial Magnetism and Electricity should jointly submit the following resolution to the general assembly of the Union: "The Union accepts the invitation of the International Meteorological Organization to cooperate with them in organizing and carrying out a second polar year with a similar object to that of the first polar year 1882–83; and appoints the following commission for this purpose: Störmer, chairman; Chapman, La Cour, Maurain, Wehrle."

The Meteorological Section of the Union was in session in the morning and again in the afternoon of August 16. At the morning session the president, Sir Napier Shaw, read the report of the bureau of the section. In it he reviewed 50 years of meteorological work with which he has been actively associated. At this time he also discussed at length relations between the meteorological section and the International Meteorological Committee. He laid down the broad principle that routine matters of administration and observation should be left to the International Meteorological Committee, and that the Meteorological Section of the Union should concentrate on research problems.

At the afternoon session M. Eredia discussed briefly his report on the choice of meteorological factors necessary to express the climatic character of a place, and stated that he did not wish to pursue the subject further, as it fell within the domain of the International Meteorological Committee. I pointed out that this was in accord with the views expressed by Professor Henry at the meeting of the Meteorological Section of the American Geophysical Union, at its recent annual meeting.

Doctor Hanzlik presented a supplement to his former report on methods of measuring rainfall. It was voted that the complete report, together with remarks by Mr. Kadel given in the Transactions of the American Geophysical Union, Tenth Annual Meeting, be referred to the International Meteorological Committee for its consideration.

On August 18, at a morning session of the Meteorological Section Sir Napier Shaw gave an interesting talk on Entropy and Tephigrams, and a few matters of minor importance were disposed of.

On August 19 the order of the day for the Meteorological Section called for the presentation of the report of the Commission on Solar Radiation. By way of introduction the chairman, Sir Napier Shaw, remarked that the most important problem now facing meteorologists is to learn the process by which solar radiant energy is converted into the energy of weather phenomena.

In accordance with principles already adopted, I requested that the "Instructions for obtaining pyrheliometric observations" be referred to the International Meteorological Committee. The request was granted. The resolutions transmitted by the American Geophysical Union, as modified by the commission were then presented and adopted.

Among the items submitted by the Bureau of the Meteorological Section of the American Geophysical Union to the Bureau of the Meteorological Section of the International Geodetic and Geophysical Union was a request from Dr. C. F. Brooks that the taking of water temperatures by vessels at sea be included in the program for the international polar year. Upon my motion, this request was referred to the International Meteorological Committee.

The following papers that had been presented before the Solar Radiation Commission were read by title with the understanding that they would be published in the volume of the Procès-Verbaux of the commission.

VOLOCHINE, F.
The International Actinometric Laboratory at Trappes.

GORCZYŃSKI, L.
Some results of the maritime actinometric measurements effected on the Atlantic and Indian Oceans in 1923 to 1928. (NOTE.—A resolution requesting that such observations be included in the program for the polar year was referred to the International Meteorological Committee.)

KALATIN, N. N.
On a study of the intensity of the radiation of the celestial vault about the sun.

BRAZIER, C. E.
Report on the actinometric work at the Parc St. Maur Observatory in 1927 to 1930.

LINDHOLM, F.
Density of the optical diffusion characterizing the atmosphere when moderately turbid.

BOEREMA, J.
Ultraviolet solar radiation on Java.

Certain other papers were then presented, among them two by H. H. Clayton on Atmospheric and Solar Variations, and on Solar and Meteorological Cycles. Doctor Rossby gave a summary of the first, and exhibited numerous diagrams, which attracted considerable attention.

At this session of the section I took occasion to resign the Chairmanship of the Commission on Solar Radiation and nominated Dr. A. Ångström as my successor, who was unanimously elected.

On August 20 the Union was taken to Uppsala to visit the university and the various institutions associated with it, including the Meteorological Institute. I confined my visit to the Meteorological Institute, the University Library, and the University Club.

On the morning of August 21 the Meteorological Section was in session from 9:45 a. m. to 11:30 a. m. It listened to papers, and tentatively adopted resolutions upon which definite action was to be taken at the final meeting of the section. There was some warm discussion over indorsing the recommendation of the International Meteorological Committee with reference to the use of the geodynamic meter instead of the meter as the unit of height in aerological studies. The British delegation generally bitterly opposed it. The American delegation voted for it, as it seemed a serious matter to refuse to cooperate with the International Meteorological Committee in this matter.

On the question of the appointment of a committee to take up the work of preparing synoptic charts of the weather in the Southern Hemisphere the American delegates voted with the British against the proposition, resulting in its defeat. Three years inactivity seemed to show that meteorologists in the Southern Hemisphere either will not or else can not assemble sufficient data to construct a synoptic weather chart for this hemisphere.

At this session Director Wallén was elected chairman of the section to succeed Sir Napier Shaw, who had stated at Prague that under no circumstances would he serve longer than three years.

On the afternoon of the 21st I visited the Meteorological Institute at Stockholm. I was especially interested in the display of Ångström pyrheliometric apparatus of different types, for measuring and recording direct solar radiation, the total radiation and the outgoing effective radiation.

On the morning of the 22d the Meteorological Section passed finally on resolutions already tentatively adopted, and adopted the report of the budget committee, with the proviso that the bureau as now constituted should have authority to change the totals allotted to different items as might seem desirable. The resolutions adopted and the report of the budget committee follow:

RESOLUTION I

Relative to the proposal of M. Eredia the Section of Meteorology states that the question as to what meteorological data are indispensable for the synthetic characterization of the climate of a given locality is a matter under the jurisdiction of the International Commission on Climatology, International Meteorological Organization. Discussion of this subject will not be entered, but the report of M. Eredia will be published in the appendix to the Proceedings of the Section as a first contribution to the study of the problem.

RESOLUTION II

The section congratulates M. Hanzlik on the important work that he has accomplished in completing his second report on pluviometric measurements. The section instructs its bureau to communicate to the International Meteorological Organization the results of the investigation by M. Hanzlik and also the views of the American Geophysical Union relative thereto, pointing out the necessity of standardizing pluviometric instruments and methods, it being understood that the charge of determining and realizing this standardization rests with the International Meteorological Organization.

RESOLUTION III

On account of the difficulties experienced in reproducing the charts illustrating the 18 reports of the practice of weather forecasting, the section instructs its secretary to communicate directly with each director forwarding such report, for the purpose of obtaining, if possible, the printing of 500 copies of the charts illustrating his report. In view of the great interest attached to this publication the section hopes that the directors will make an effort to comply with the request that will be addressed to them.

RESOLUTION IV

The section is agreed relative to the limiting in a general manner of the privileges of the section to the study of the meteorological questions that call for collaboration with one or more of the branches of geophysics that do not depend on the International Organization. The sphere of the section should be extended to other questions that may have practical applications, which, however, are yet in the period of scientific incubation, and the crystallization of which necessitates exchanges of views between experts before the International Meteorological Organization can take useful cognizance of them. Sufficient time should certainly be reserved for the proper discussion of scientific subjects.

The work of the section would consist, then, chiefly of the discussion of scientific questions. It may be remarked here that the Union does not intend to replace the usual means of publication of scientific ideas. The question of cooperation between the organizations should be capable of adjustment, but only after experience.

RESOLUTION V

Because of the importance given to isentropic surfaces by Helmholtz, Margules, and others, the International Meteorological Organization is requested to take under consideration the possibility of introducing into the publication of daily observations the data necessary for the calculation of the entropy of the air.

RESOLUTION VI

The Radiation Commission emphasizes the importance of defining the turbidity of the air in a simple quantitative manner in order that it can easily be used in synoptic studies and eventually included in synoptic wireless issues.

The attention of the International Meteorological Organization is drawn to this matter, and reference is made to the works of Linke, Kimball, and Ångström, where such definitions are proposed. It is suggested that the gentlemen mentioned might be asked to collaborate.

RESOLUTION VII

As a consequence of the statement of the problem of atmospheric ozone by Doctor Dobson, the section approves the general program of research outlined by him, and expresses the importance that it attaches to these researches.

The section approves the appointment by its commission on solar radiation of a subcommission on atmospheric ozone, consisting of Messrs. Abbot, Ångström, Chalange, Dobson (chairman), Fabry, Götz, Kimball, and Ladenburg.

RESOLUTION VIII

Realizing the importance of a final conclusion regarding the establishment of an absolute pyrheliometer, the section expresses the hope that the Commission on Solar Radiation, International Meteorological Organization, will press on with the investigations that they initiated at their meetings at Davos and Copenhagen. (See Resolutions II, III, and IV, Davos Session and Resolution IV, Copenhagen Session.)

RESOLUTION IX

The Meteorological Section welcomes the establishment in Trappes, by the help of the Czechoslovakian Government, of a central actinometric institute which will cooperate with the institutes at Potsdam, Stockholm, Washington, and Parc Saint Maur in investigations directed toward the production of a standard actimometer.

The section trusts that the work will continue to be supported by the Czechoslovakian Government.

RESOLUTION X

The Commission on Radiation has examined with interest the draft copy of a bibliography of works on radiation which Professor Voloschine proposes to prepare and publish. In view of the usefulness of such a bibliography the commission recommends that the Meteorological Section make a contribution toward the cost of publication.

Professor Voloschine estimates that the cost of preparation and publication will be approximately £500.

RESOLUTION XI

The section recommends the systematic observation of rains of mud in the regions where they are not rare (for example, in the western Mediterranean basin) and the collaboration of meteorologists and mineralogists with the view of determining (*a*) the frequency of the phenomenon, (*b*) the origin of the dust and the path of the particles, (*c*) the variations in the composition of the mud either by progressive sedimentation in the atmosphere or as a function of the location relative to dust currents, (*d*) the class of clouds associated with the phenomenon and their direction, and (*e*) the accompanying optical phenomena.

RESOLUTION XII

Connection with oceanography. The section notes that there are important relations between the extension of polar ice and the seasonal character of the weather over large areas. It considers that the present information on ice is not so complete as it might be and that it would be very interesting to develop it by means of an international organization particularly during the polar year.

RESOLUTION XIII

On learning the ideas of M. Lugeon on sounding by atmospherics (*Sondage par les atmosphériques*) and considering their interest from the viewpoint of dynamic meteorology, the section expresses the desire that similar researches may be pursued in different countries. The section calls the attention of the International Scientific Radiotelegraphic Union to this matter and points out to the Commission on Atmospherics of that organization the interest that there would be from the meteorological point of view in organizing an international network for recording atmospherics especially during the polar year and in collecting and publishing the results.

SCHEME OF THE BUDGET OF THE SECTION OF METEOROLOGY

The financial report placed before the session by the bureau of the section anticipated after balancing receipts and expenditures for 1927–1930, a credit balance of 25,869 francs. Since, however, the total of the apportionments for 1928 and 1929 amounted to 98,099 francs instead of 59,000 francs, as anticipated in the report based on the apportionment of 1927, the credit balance is now found to be 64,986 francs.

In addition, the annual apportionment to meteorology for the next fiscal period will probably be carried as 100,000 francs. There are, then, 365,000 francs that will be at the disposal of the section in this next 3-year period.

CREDITS

	Francs
Balance for the period 1927–1930	64, 968
Apportionments for the period 1930–1933	300, 000
Total credits	364, 968

DEBITS

	Francs
Expenses of the bureau (correspondence through the secretariat and printing)	37, 000
Expenses of one session of the bureau between the sessions of the Union	12, 378
Subscription to the publication of La Haute Atmosphere (3 years)	27, 851
Subscription to the publication of Charts of the Northern Hemisphere	60, 000
Contribution toward the publication of the bibliography of solar radiation compiled by the Actinometric Library at Trappes (recommended by the Commission on Solar Radiation)	62, 500
Grant to the polar year in the form of a prize to be given for the first model of an automatic meteorological station giving satisfactory results and put into working order before Jan. 1, 1932	50, 000
Grant to the projected experiment in short-range forecasting from pressure charts after the new method of M. Giáo based on hydrodynamics of disturbances	40, 000
Total expenses	289, 729
Reserve	75, 239
Total debits	364, 968

At 12:20 p. m. of the 22d Doctor Ångström conducted a party that included Doctor Gorczyński, Professor Linke, Doctor Götz, and myself, to Stocksund, to visit the pyrheliometric observing station. It is well located on a hill in the open country more than a half hour's automobile ride from Stockholm. The observer, Mr. Aúren, lives in the observatory building with his family. Most of the instruments are photographically recording, and few check readings are made.

Professor Linke proposed informally that the name *Langley* be used to designate the unit of solar radiation instead of the present cumbersome expression "gram-calories per minute per square centimeter." Later he stated that some of the leaders in solar radiation research had agreed to join him in using this name in future papers. I did not agree to join them in this invitation until I had had opportunity to consult with Professor Marvin and Doctor Abbot.

The final meeting of the Union was scheduled for 10:30 a. m. of August 23. It convened shortly before 11 a. m. The question of adopting proposed changes in the constitution was on the agenda. As each proposed change was read the president asked that consideration be deferred until the next meeting, three years hence. There were murmurs of dissent, but the president had his way until the amendment was reached which provided that a president should not be eligible for reelection at the expiration of his term of office. The president asked that action on this amendment be deferred also, but Doctor Simpson, of England; Doctor Bowie, of the United States; Professor Mercanton, of Switzerland, and others, protested that if this policy of postponing action on every disputed question was continued, none of them could expect to again be sent as a delegate to an assembly of the International Geodetic and Geophysical Union.

After considerable delay the amendment was finally adopted, Belgium alone voting against it.

Lisbon, Portugal, was selected as the place for the assembly in 1933.

This was not only the largest general assembly of the International Geodetic and Geophysical Union yet held but, as far as the meteorological section was concerned, the most successful. More definite research problems were discussed and acted upon than at any previous meeting, and there was more cooperation with other sections, notably the sections of oceanography and terrestrial magnetism. I am of the opinion that too much time was taken up by the presentation of unimportant papers, and that the Bureaus of National Unions should scrutinize with more care resolutions and papers that are presented to it for transmission to the Bureau of the International Union.

The outstanding problem for the next three years is the financing and carrying out of the program for the international polar year, 1932–33. Doctor La Cour and others who are developing the program are hoping for financial aid, not only from Governments but also from scientific institutions. Since this is the fiftieth anniversary of the Greely expedition it would seem that institutions in the United States should respond generously.

CLIMATIC CONDITIONS IN THE LOUISIANA PURCHASE AS FOUND BY LEWIS AND CLARK IN 1804 AND 1805 [1]

By G. K. GREENING, United States Weather Bureau, Sioux City, Iowa

At sunrise 125 years ago to-day (December 27, 1929) the only thermometer of record in that vast stretch of country from the middle Missouri Valley to the Pacific Northwest read −4° F. The prized instrument was included in the equipment of Capt. Meriwether Lewis, in charge of a party of 43 men, who were on a journey of exploration, afterwards known as the Lewis and Clark expedition. Starting in Illinois opposite the mouth of the Missouri River on May 14, 1804, the expedition disbanded at St. Louis, Mo., after 2 years 4 months and 9 days of varied experiences and hardships, yet with an outstanding record of scientific achievement. The temperature reading referred to on December 27, 1804, was made at Fort Mandan, N. Dak., where America's pioneer meteorologists were in winter quarters not far from the present location of Bismarck.

It is a striking coincident that the given name of the first official weather observer to traverse the United States from the Atlantic to the Pacific Oceans via the Ohio, Mississippi, Missouri, and Columbia Rivers should be Meriwether. The euphony of the appellation suggests that the pathfinders of our trans-Missouri domain always encountered fair sailing over the "boils" and "sawyers" of the turbulent Missouri River, which, nevertheless was far from true, as the meteorological register kept on that famous voyage shows. The weather diary kept by the explorers, Capts. Meriwether Lewis and William Clark themselves personally is now in the possession of the American Philosophical Society, Philadelphia, Pa. The daily rise and fall of the principal rivers was noted as carefully as the thermometer and the state of weather.

The original register was kept by Captain Lewis in a book that he had previously used while paymaster in the Army in 1800, and in which he entered his weather diary from January, 1804, to April, 1805. Exceptional care must have been exercised to safeguard the records over a hazardous journey estimated by the explorers to have been 7,689 miles, as shown by the following letter from Librarian Laura E. Hanson, of the American Philosophical Society, dated October 29, 1929: "The original manuscript journals of the Lewis and Clark expedition are in the possession of this society and these journals contain the weather diary kept by the explorers. These are in excellent condition and very easily read."

President Thomas Jefferson, in a secret message to Congress in 1803 requesting $2,500 to explore the western country that made the records possible, said "that the Missouri River traverses a moderate climate, offering, according to the best accounts, a continued navigation from its source and possible with a single portage from the western ocean." Two thousand five hundred dollars seems a trivial sum for such an undertaking to-day; but it must be remembered that Iowa farm land was purchased by Thomas Jefferson, who was making the request, for between 2 and 3 cents an acre, and a private soldier in the United States Army in 1803 was paid $5 a month for his services. The expedition, while being scientific, was also strictly military.

Keeping of weather records was an interesting diversion from statecraft for the founders of our Government, and Thomas Jefferson was no exception, as the instructions written by him to Captain Lewis on June 20, 1803, proves. He instructed him to record the "Climate as characterized by the thermometer, by the proportion of rainy, cloudy, and clear days, by lightning, hail, snow, ice, by the access and recess of frost, by the winds prevailing at different seasons, the dates at which particular plants put forth or lose their flowers or leaf, and times of appearances of particular birds, reptiles, or insects."

These instructions were carried out to the letter where it was humanly possible, and the records will bear me out in that statement. A few examples follow: Lewis and Clark's measurement of the distance from the mouth of the Missouri River to Sioux City, Iowa, was 850 miles, or 43 miles more than the United States engineers' measurement 100 years afterwards over a channel that is known to change abruptly from year to year.

Point of observation No. 33, in their astronomical observations 4 miles above the present location of Sioux City, taken on a large sand bar, was given as latitude 42° 28′ 29″ and the reading as used at present is 42° 29′, or a difference of 31″.

The lone thermometer that started the journey was carefully tested on January 1, 1804, when records were begun, using water and snow mixed to determine the freezing point and boiling water to test the boiling point on the instrument.

Precision must have been used in noting the time, as is well shown in the observation of a total lunar eclipse on the night of January 15, 1805, at Fort Mandan, N. Dak., from 12 midnight until 3 a. m. In a letter, dated October 3, 1929, Mr. James Robertson, director of the American Ephemeris, has the following to say with reference to this eclipse: "From the British Nautical Almanac for 1805 (confirmed by the French Connaissance des Temps) we obtain, by applying equation of time and longitude, the following local mean times at Mandan, N. Dak., for the circumstances of the total lunar eclipse of 15 January:

Eclipse begins	12:08 a. m.
Totality begins	1:06 a. m.
Middle of eclipse	1:56 a. m.
Totality ends	2:45 a. m.
Eclipse ends	3:43 a. m.

"For apparent local times, substract 10 minutes. For mountain standard time, subtract 16 minutes." From the foregoing information, the eclipse should have first been noted at Fort Mandan at 11:58 p. m., January 14, 1805, or within two minutes of the time mentioned as first observed, which is unusually close for amateur astronomers out of touch of civilization.

The first mention of frost in the diary was on October 5, 1804, near Mobridge, S. Dak., or 19 days later than the average first frost in that locality. The first killing frost was observed near the mouth of the Cannonball River in North Dakota on October 18, 1804, when the thermometer at sunrise registered 30°. For that section it was about seven days later than the average date for the first killing frost.

Snow was first seen on October 21, 1804, when it fell to the depth of one-half inch near Bismarck, N. Dak., where usually the first snowfall of that amount is November 6.

On November 13, 1804, at 10:30 p. m., drift ice began to run in the Missouri River at Fort Mandan, and on November 30 the river was frozen over so that it could be crossed on the ice, which was three days later than the average closing in that locality. Great herds of buffalo crossed the Missouri River near the fort 10 days after it

[1] Presented before American Meteorological Society, Des Moines, Iowa, Dec. 27, 1929.

closed. (As many as 20,000 buffaloes were seen at one time by the explorers.) The ice gave way in the river about 3 p. m. March 26, 1805, and came down in immense sheets, giving a closed season for navigation at Fort Mandan during the winter of 1804–5 of 116 days, or 9 days less than the Bismarck (N. Dak.) average.

The sergeant of the guard wakened the party to observe "northern lights" on the evening of November 5, 1804.

The annual "big flight" of wild geese, ducks, and brants started on November 9, 1804, which is not far from the average date. It is interesting to note that a mallard duck was always referred to in their journals as a duckanmallard. The wild geese usually nested in the top of broken trees, sometimes in the fork of a large tree, but almost invariably from 15 to 20 feet or upward high.

The first zero temperature at Fort Mandan, N. Dak., was recorded on December 7, 1804, in connection with a severe cold wave that lasted until the 19th. The average date for the first zero temperature at Bismarck is November 25 or 12 days earlier than in the winter of 1804–5 at Fort Mandan.

On April 1, 1805, the first thunder of the season was heard. It attended the first shower of rain witnessed since September 15, 1804. Captain Lewis noted that he had observed that all thunderclouds in the western part of the continent proceed from the westerly quarter, as they do in the Atlantic States. Another noteworthy conclusion of the earliest of field workers in the realm of the new science of meteorology while quartered on the Pacific coast, and written on January 31, 1806, says: "The winds from the land brings us cold and clear weather while those obliquely along either coast or off the ocean brings us warm, damp, cloudy, and rainy weather. The hardest winds are always from the southwest." This statement regarding wind and weather conditions on the north Pacific coast is substantially in accord with the facts, according to E. H. Bowie, district forecaster, Weather Bureau office, San Francisco, Calif. Thomas R. Reed, in Rain-bearing winds of the Far Western States, MONTHLY WEATHER REVIEW, May, 1927, says, "Given a reasonably free exposure, the rain-bearing surface winds are preponderantly from southerly quarters" and "Infrequency of precipitation with east winds in the far West is a phenomenon of special note."

A graphical account of a hailstorm encountered at the present site of Great Falls, Mont., illustrates the severe privations which the elements meted out to the party on June 27, 1805, when the following entry was made: "At 1 p. m. a black cloud which arose in the southwest came on, accompanied with a high wind and violent thunder and lightning; a great quantity of hail also fell during this storm, which lasted about two hours and a half. The hail, which was generally about the size of pigeon eggs and not unlike them in form, covered the ground to one inch and a half. For about 20 minutes during this storm hail fell of an enormous size, driven with violence almost incredible; when they struck the ground they would rebound to the height of 10 to 12 feet and pass 20 or 30 before they touched again. During this immense storm I (Captain Clark) was with the greater part of the men on the portage. The men saved themselves, some by getting under a canoe, others by putting sundry articles on their heads. Two were knocked down and several with their legs and thighs much bruised. Captain Lewis weighed one of those hailstones which weighed 3 ounces and measured 7 inches in circumference; they were generally round and perfectly solid. I am convinced if one of those had struck a man on the naked head it certainly would have fractured his skull." The word "blizzard" had not been coined at that time to describe a severe snowstorm, and consequently the expression does not appear anywhere in their journals. As a matter of fact, the term "blizzard," did not come into general use until about 1870. Previously, however, in the fifties and sixties, a Dakota blizzard was called "pouderie" among the French settlers, meaning powder mill—the force of which will be appreciated by anyone who has had a blizzard burst upon him.

Their phenological observations were recorded somewhat on the order of those now published in the Quarterly Journal of the Royal Meteorological Society, but, of course, were less comprehensive. Many new species of both animals and plants then unknown to the world were discovered.

Zoological notes were kept and anything of peculiar interest was noted. For instance, we are often called on to explain various unbelievable occurrences in connection with tornadoes. I recall a discussion at the Kansas City meeting of the American Meteorological Society in December, 1925, as to why fowls lost their feathers in such storms. The observations of Lewis and Clark in their description of the pelican answers the question in part, at least. They say "The thigh is covered with feathers within a quarter of an inch of the knee. It has a curious frothy substance which seems to divide its feathers from the flesh of the body and seems to be composed of globules of air and perfectly embraces the part of the feather which extends through the skin." Nature has made it easy to remove the feathers of a fowl, and the sudden change in air pressure with the passage of a tornado acts to cause an outward pressure from the base of the feather that could very easily account for the "picking" of a chicken or duck that may happen in the path.

Although we have recited only a few items that should interest members of the Meteorological Society from the original journals and weather diary of the Lewis and Clark expedition they show the unquestioned loyalty of the members of that party to the leaders of the expedition and how carefully and conscientiously Thomas Jefferson's instructions to Captains Meriwether Lewis were carried out. In fact, the records themselves are worthy of emulation by modern weather observers.

We can not refrain from giving two or three notations relative to the thermometer that would have been the first to cross the United States if fate had served it more kindly. On July 22, 1805, while located near Helena, Mont., Captain Lewis wrote: "I placed my thermometer in a good shade as was my custom, about 4 p. m., and after dinner set out without it. I sent Sergeant Ordway back for it. He found it and brought it on." On September 6, 1805, this notation was made, "Thermometer broke by the box striking against a tree in the Rocky Mountains. No further readings after September 5, 1805." And on January 3, 1806, while on the Pacific coast, the last reference is found when the leader of the party wrote: "The loss of my thermometer I most sincerely regret. I am confident that the climate here is much warmer than in the same parallel of latitude on the Atlantic Ocean, though how many degrees is now out of my power to determine."

Although the thermometer did not live to give an early temperature record of the north Pacific coast, happily it served a valuable purpose during the winter of 1804–5 in the center of the continent at Fort Mandan, N. Dak. A comparison of temperature records as kept by the explorers 125 years ago and now shows no radical diver-

sions, although we must admit that the explorers chose a cold winter to visit North Dakota. The records from the Bismarck (N. Dak.) station for comparative purposes have been furnished through the courtesy of Mr. Orris W. Roberts, official in charge of the Weather Bureau office at that station. Captain Lewis or Captain Clark read their only thermometer themselves personally at sunrise and 4 p. m. each day and entered the readings in the meteorological register.

A computation of the mean temperature from November to March, inclusive, at Bismarck from November, 1924, to March, 1929, discloses that the monthly mean temperature at that place averaged 0.7° lower than the mean of the temperature at sunrise and 4 p. m. Deducting that amount from the mean monthly temperature for the winter months of 1804–5 as shown in the Lewis and Clark record gives a fair comparison with modern Weather Bureau records at Bismarck, N. Dak.

Using a −.7° correction to the mean of the sunrise and 4 p. m. readings during the winter of 1804–5 to reduce the temperature to a monthly mean basis, Lewis and Clark would have obtained the following results at Fort Mandan: December, 1804, 3.1°; January, 1805, −3.9°; and February, 1805, 10.5°.

The records show that Lewis and Clark encountered the coldest December and January combined of record in the vicinity of Bismarck, although December, 1879, and December, 1927, were colder than in 1804; and January, 1875, 1887, 1888, and 1916 averaged lower than January, 1805. The minimum temperature at Fort Mandan for December, 1804, was −43° on the 17th, which was 1° lower than the absolute December minimum at Bismarck established on December 20, 1916. November, 1804, was 4.2° warmer than the 55-year average at Bismarck, February, 1805, 0.2° warmer, and March, 1805, 3.5° warmer.

A perusal of the interesting initial diary of the Missouri Valley does not disclose, however, that the climate 125 years ago in the home of the tornado and the blizzard differed much from what it is to-day. The original engineer of the Great Plains, the American bison, who followed the lay of the land and the run of the water, thrived in vast herds under similar climatic conditions and less protection than the horse, cow, and sheep do to-day.

Delving into old records and getting the viewpoint of past generations holds a fascination and it has amply repaid me for the reading of the Original Journals of the Lewis and Clark Expedition, printed from the original manuscript and now in the possession of the American Philosophical Society. Most of the subject matter of this paper was obtained from that source. One of the happy rewards for a person who has been studying stream flow in the Missouri River for years was the discovery of what is probably the origin of the fallacy that the annual rise in the middle and lower Missouri River, commonly known as the June rise, is due to the melting snows in the northern Rocky Mountains.

The Lewis and Clark expedition were detained about seven weeks in the northern Rockies on the return journey in consequence of the snow, and the experiences encountered lead Captain Lewis to write, on June 2, 1806: "I have no doubt but that the melting of the mountain snow in the beginning of June is what causes the annual inundation of the lower portion of the Missouri River from the first to the middle of July." This mistaken idea persists in the minds of a large percentage of the dwellers of the Missouri Valley. Its origin may have been in the statement just read, although the explorers may have been mislead by the Indians, who are in many cases not interested enough in rivers even to give them a name. As an example, the Columbia River has no name among any of the tribes living on it. The cause of high water during June and July in the middle Missouri River was shown by Charles D. Reed in his article on "Floods of the upper Missouri River," MONTHLY WEATHER REVIEW, June, 1911, to have been due to heavy rainfall, with the mountain snowfall exerting a negligible influence.

Speaking of rivers, it is worth while to recall that while Captain Lewis was descending the Ohio on the outward journey he wrote to President Jefferson, from Wheeling, W. Va., on September 8, 1803, as follows: "The River (Ohio) is lower than it has been known by the oldest settlers in this country. On many bars the water in the deepest part does not exceed 6 inches." Again, on October 3, at Cincinnati, Ohio, he remarked, "The water still continues lower in the Ohio than it was ever known."

Lewis and Clark named many rivers of the Northwest. They terminated the name of the Missouri River at Three Forks, Mont., and on July 28, 1805, the following entry appears in their diary: "Both Captain Clark and myself corresponded in opinion with the impropriety of calling either of these streams the Missouri and accordingly agreed to name them after the President of the United States and the Secretaries of Treasury and State, having previously named one river in honor of the Secretaries of War and Navy. In pursuance of this resolution we called the southwest fork, that which we meant to ascend, Jefferson River in honor of that illustrious personage, Thomas Jefferson (the author of our enterprise), the middle fork we called Madison River in honor of James Madison, and the southeast fork we called Gallatin River in honor of Albert Gallatin."

I have endeavored to set out not only weather conditions of interest as found by Lewis and Clark on their great expedition of exploration but other items of public interest as well in this new era of developing what ought to be the longest river in the world, the Missouri—a river with a romantic past and a useful future.

MUD FLOODS IN UTAH

By J. CECIL ALTER

[Weather Bureau Office, Salt Lake City, Utah]

Numerous rapid and heavy local downpours of rain during the first two weeks in August produced an extraordinary number of washing floods in the mountain sections of Utah, several of them similar to the destructive earth washes of July 10, 1930, between Centerville and Farmington.

The first of these floods, on the afternoon of August 2, flooded an area of approximately a square mile of industrial section in northwestern Salt Lake City with slime, gravel, and rocks from the steep, smooth mountain side adjacent, and from the caving walls of gravel pits and other excavations. Rivers of mud ran down the streets and roads and over a wide area of improved premises, while in the more concentrated parts of the avalanche great masses of moraine gravel and rocks were transported and deposited into depressions, more especially in the cut through which the State-paved highway passes parallel to the foot of the slope.

One flow of mud and earth from 400 to 500 feet wide and about 2,000 feet in length, left a ridge of earth 4 feet deep on the paving just north of Warm Springs. A quarter of a mile farther northwest where the paving passes for about 2,000-feet through a cut from 15 to 20 feet in depth in the ancient moraine there were three gravel washes from 300 to 500 feet wide that filled the cut from a quarter to half full. (See fig. 1.) Another huge wash crossed the open roadway near Becks Hot Springs, 1½ miles farther northwest, where basements and premises were flooded with water dammed up by the railroad grades. The total loss and repair expense resulting from this flood is estimated at $25,000.

On August 8 a rapid flow of water, mud, and rocks dashed out of a shallow gully in the face of the mountain just north of Cedar City, Iron County, depositing earth and bowlders across the State highway to depths of 1 to 3 feet, and covering an area 200 or 300 feet wide and about 1,500 feet long. A little farther north in Parowan Canyon on the same afternoon, and repeated on the 10th, the headworks of the municipal water system and some of the water lines were badly damaged by sudden rushes of water resulting from local canyon rains.

August 9th: An immense flood dashed out of Cottonwood creek, Emery County, destroying irrigation works and filling canals at Orangeville and Castle Dale; in Ophir Canyon, Tooele County, the highway and the powerhouse pipe line were considerably damaged by floods of mud and water; and at Bountiful, Davis County, water overflowed the streets, watering some basements and flooding some land in truck crops. Simultaneously the old mud flood of August 2, near Becks Hot Springs, in Salt Lake City limits, was overrun again, re-covering the State highway paving with mud, and burying the adjacent tracks of an interurban electric railroad. Also at this time another rush of water on top of the old mud flood of July 10 at the south edge of Farmington, Davis County, still in impressive evidence, refilled part of the excavation made through it on the paved highway and extended the area covered, reaching the interurban tracks which it covered to a considerable extent. At Promontory, Boxelder County, a heavy local rain on the 8th and 9th damaged railroad property and improvements, stranded several automobiles on the highway, and flooded and silted a few business and residence basements and premises.

The culmination of this series of floods began toward noon on Monday, August 11, when a heavy downpour of rain on the Oquirrh Mountains augmented the damage done at Ophir on the 9th, shot a considerable acreage of gully mud and gravel to the mouth of Mercur Canyon, and ejected a roaring torrent of water, mud, and rocks out of Carrs Fork into Markham Gulch, a branch of the narrow canyon town of Bingham, near the Salt Lake-Tooele County line, crushing or half burying about 20 Utah Copper Co. cottages and a few privately owned residences, caving in the rear wall of the company hospital rather badly, crushing an automobile and several outbuildings and fences, breaking a few telephone and electric lines, and piling rocks and slimy earth to a depth of from 1 to 15 feet for a distance of several rods in the settled part of the canyon and a considerable distance above. (See fig. 2.) The duration of this flood was about two and one-half hours. Property loss and immediate rehabilitation expense will be at least $75,000.

Before the thundering avalanche at Bingham had become silent a torrential rain set in along the west slope of the Wasatch Mountains north of Salt Lake City, which not only started several minor flows of sand and gravel, but at Centerville, Davis County, rapidly sluiced an immense island of mud into the northern edge of that village and over the adjacent fruit and truck growing areas, wrecking or rendering uninhabitable seven or eight good residences and destroying barns, outbuildings, fences, implements, tools, irrigation waterways, nursery stock, and growing or unharvested crops, and covering and damaging an area of land several hundred feet in width and a half mile in length, and almost totally destroying the value of about 50 acres of valuable land, now badly washed, and piled and littered with rocks and huge bowlders, many of them from 50 to 100 tons in size, and a few estimated to weigh as much as 150 tons each. The large Centerville public-school building was badly damaged by breaking windows, caving in the east wall, and filling up the yard in places above the main floor, while the State-paved highway was covered deeply with mud and rock for a distance of nearly a thousand feet.

Simultaneously a similar cascade of great turbulence came out of Ford Canyon, 1½ miles farther north, which deposited a tract of mud from 1 to 6 feet deep, several hundred feet wide, and about three-quarters of a mile long, covering interurban railroad tracks and necessitating detouring and portaging passengers and freight for some time, and burying the State-paved highway so badly it has been decided to erect thereon a structure several feet high and about 1,500 feet in length. Four or five dwellings were destroyed, along with their premises, outbuildings, and much property, including the crops on a large acreage of land as well as the temporary usefulness of most of the land, and the permanent usefulness of about 25 acres of crop land and orchards; and a dozen cows and more than a thousand chickens and some other livestock. In these two floods about 200 acres of crops were destroyed or badly damaged, some of the land being permanently ruined, though in use for many years past. The total immediate loss will be about $125,000.

The next day, Tuesday, August 12, moderate floods went across the state-paved highway at Springville, Utah County, damaging the State and Federal fish hatcheries somewhat; and at Ironton, near by, where some débris was deposited on the paving and in the fields. The city of Ogden was drenched with a widespread sheet of running water causing moderate damage, while another flood ran across the paving near Willard, Boxelder County, damaging some farm lands near by. A similar flood of mud occurred at Grantsville, Tooele County, where the highway was heavily covered with earth, and several cellars and ground floors were more or less mudded and wetted. A flow of muddy water ran through the town of Tooele, Tooele County; and the premises of the Arthur Mill, near Garfield, Salt Lake County, were partly overrun with mud from a local gully wash, watering and silting some boiler rooms and other subsurface floors. At Magna, near by, a considerable head of water and mud splashed through the business district, moving two dwellings from their foundations, silting several homes, and wetting and mudding the storeroom floors of several retail establishments. An estimate of the loss caused at Magna and Arthur (including a little further damage at Arthur on the 13th) is about $25,000.

Still further on August 12, several minor sand and gravel runs started by heavy rains crossed the highway in Parleys Canyon, near Salt Lake City; and at the same time the earlier mud deposits between Centerville and Farmington were again overrun with water, hindering the work of rehabilitation and making matters worse in some respects. Ophir Canyon suffered further washing injury, and the Bingham mud deposit of the 11th was again overrun resulting in some further damage and incon-

(To face p. 320)

FIGURE 1.—Automobile buried in mud flood of August 2, 1930, in highway cut at northwestern edge of Salt Lake City, Utah. The car, suddenly halted by the flood, was buried in about 30 minutes. Five passengers escaped

FIGURE 2.—Street in Markham Gulch (upper Bingham), Utah, following the mud flood of August 11, 1930

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venience, while American Fork Canyon sent a flood of mud and rocks onto the adjacent grain fields and over the roadway, near Alpine, Utah County. At Mount Emmons, some fields and roads were flooded and a cow drowned; and near Moroni, Sanpete County, highways, fields, and crops suffered damage in excess of $500. The mountain highway between Richfield and Fish Lake, Sevier County, was closed by mud washes, necessitating long detours. The heaviest earth wash on this date came out of Snowslide Gulch in Provo Canyon, Utah County, just above Donnan's Upper Falls Resort, where about noon a run began which in a short time laid down a body of mud that extended entirely across the canyon and buried the highway from 1 to 8 feet deep for a distance of nearly 500 feet. Provo River was dammed up to a height of 2 feet above the railroad tracks, and a power company water flume was considerably damaged. Automobile traffic was towed through the pool of water for two weeks, though drag lines lowered the water level away from the railroad in a few days.

Other deluging rains on Wednesday, August 13, augmented the flood conditions in all the damaged areas in Davis, Salt Lake, Toocle, and Utah Counties. The interurban electric railroad near Farmington was covered with mud again, and the track was undermined by running water just north of town. The highway excavation through the Ford Creek flood was so badly refilled, the project was abandoned and a corduroy detour constructed over the débris to one side. New mud washes in Provo Canyon hampered the work of repairing the highway, and marooned several automobiles between the floods of mud. A second flood of mud ran through the premises of the Arthur ore concentrating mill near Garfield, silting the works extensively with mud, which can be removed from many places only at heavy expense. A large concrete highway bridge over Price River between Helper and Price, Carbon County, was undermined and broken down, the flood waters also breaking two water pipe lines. Silver City, Juab County, suffered from a rush of water through the village, while over toward Elberta, Utah County, heavy floods tore their way down Big Government Canyon, damaging a bridge and several miles of railroad. Three cottages were carried away at the Apex mine, and the highway and a considerable acreage of farming land were overflowed, largely with mud, near Elberta.

Though measurements of rainfall at substations in the vicinity of flooded areas appear to bear no very consistent relation to the magnitude of the various floods, it is perhaps significant that the total rainfall for the State during August was about two and one-half times the normal amount.

CLIMATIC CYCLES

By PROF. ALBERT W. GILES

[University of Arkansas, Fayetteville, Ark., August 1, 1930]

In the MONTHLY WEATHER REVIEW of December, 1929, Doctor Marvin describes a simple apparatus devised to illustrate graphically cycle recurrences with variable length of both period and amplitude. The device, which is designated an "harmonic analyzer," possesses elements which may be readily made continuously and irregularly variable during its operation, resulting in a curve representing any desired irregularity in period and amplitude of the cycles composing the sequence illustrated by the curve. An equation by Fujiwhara is cited by Doctor Marvin as the first attempt to analyze mathematically the problem of periodicities with variable length and amplitude. In concluding his article Doctor Marvin very properly advises that "we should not require one mechanical model of this kind to represent all the details of a complex periodic curve, but rather the problem is to find a comparatively few elements having individual and separate variable amplitudes and periods of their own, which in combination produce the complex curve nature gives us."

The continuous changes marking the progress of climate through the ages would seem admirably adapted to representation as a curve involving cyclical recurrences possessing variable length of both period and amplitude. But climate is a composite consisting of several elements each of which is irregularly variable, and variation in one need not and frequently does not coincide with variation in the other elements. Hence the superposition of the curves representing the histories of the several climatic elements upon a grid or other graphic base would only result in a network characterized by the absence of harmonic or mathematical precision.

Even the graphic representation of a single element of climate is difficult, particularly when the curve is extended backward to illustrate the history of that climatic element in its progress through geologic time. The difficulty, of course, may be largely overcome by considering only the contemporary history faithfully recorded instrumentally, but after all the progress of climate through the ages is an interesting and vital part of climatology, a part that may throw light upon present climatic conditions, just as the history of organisms through the ages is a part of biology and an aid to the biologist in his interpretation of biologic factors, as, for example, contemporary distribution of organisms, the origin of vestigial structures, and evolution.

The essential elements that comprise the composite called climate are temperature, pressure, wind direction and velocity, humidity, cloudiness and sunshine, amount and kind of precipitation, and types of storms. A detailed description of the climate of a locality or a region would include not only the daily, monthly, seasonal, and annual averages for each of the climatic elements, but also indicate significant daily, monthly, seasonal, and annual departures from the averages. Obviously, the more detailed the description of the climatic elements, the larger the number of climatic provinces that may be differentiated. For the United States 10 climatic provinces are recognized and described by Ward in his Climates of the United States. On the other hand, a map recently published describes the "climates" of Maryland and Delaware, representing a very refined classification. But using the refinement in classification comparable to that of Ward it is possible to recognize probably 25 or more climatic provinces in North America.

In going back into geologic time the evaluation of climatic elements becomes increasingly difficult. As a result, temperature is the element usually considered, the others being wholly neglected or their importance inadequately summarized. It is highly probable that certain elements of climate, such as humidity, average sunshine, and average cloudiness, can never be more than roughly estimated for most of the geological periods; on the other hand, it is reasonably certain that the climates of the geologic past will be eventually much more thoroughly understood in details and in duration than they now are.

Again, the interpretation of geologic climate suffers from broad and vague generalization. Land areas of great extent in latitude and longitude are often considered as possessing one type of climate persisting through spans of millions of years. The climate of geologic periods is frequently summarized in standard texts of historical geology as "mild from pole to pole," a generalization often based on the distribution of marine faunas. Such statements are vague, inaccurate, and meaningless. Land masses of significant dimensions must always have experienced a variety of climates, and as knowledge of paleogeography increases it will be possible eventually to block out roughly climatic provinces of the past.

Temperatures alone is the most significant climatic element and in turn exerts a marked influence upon the other climatic elements. Although the march of temperature through the ages is known only in a very broad and general way, yet it is possible to attempt the construction of a curve, following the suggestion of Doctor Marvin, representing its fluctuations during the progress of time. Possibly the simplest method of approach to the problem is the plotting of a curve representing departures from the mean annual temperature for a station whose instrumental records go back over a considerable period of time. For this purpose Little Rock, whose temperature record is known for a half century, has been selected as typical. The annual means have been supplied by Mr. Cole, meteorologist in charge of the station. The average annual temperature of Little Rock is 62.1° F., based on a record of 50 years, of which 23 years show a positive departure and 26 years show a negative departure, the greatest positive departure being 1.9° F and the greatest negative 2.3° F. The results are graphically illustrated in top curve in Figure 1. The resulting curve is obviously asymmetric and illustrates very well cyclical recurrences possessing variable length of both period and amplitude. The effect of the 11-year sunspot cycle, the Brückner cycle, and other possible cycles which should be reflected in a rhythmic periodicity in the curve is apparently masked by temperature effects produced by other factors.

Since temperature is an irregularly fluctuating climatic element continuously in operation, it is possible theoretically to plot its trend through all four sets of temperature cycles as a single curve, but practically there are serious difficulties in the way of its accomplishment. These difficulties arise from the brief duration of the tertiary and quaternary cycles as compared with the enormous duration of the primary cycles. To depict accurately the former cycles on a curve showing the primary and secondary cycles the drawing would necessarily be of such dimensions as to be unwieldy.

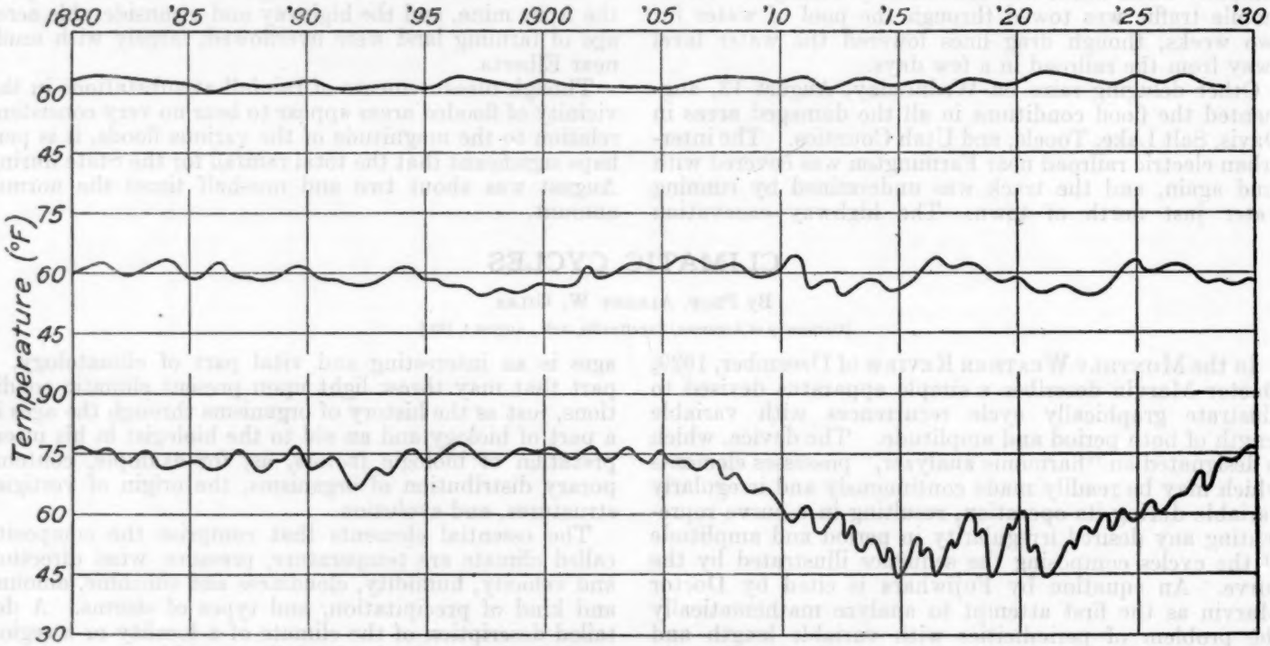

FIGURE 1. *Top curve.*—Diagrammatic representation of the character of temperature pulsations affecting localities within brief periods of time, designated as quaternary cycles. Length of time represented by curve is 50 years

Middle curve.—Diagrammatic representation of the character of temperature pulsations affecting areas of regional extent within the historic period, designated as tertiary cycles. Length of time represented by curve estimated in terms of thousands of years.

Bottom curve.—Diagrammatic representation of the character of temperature pulsations affecting areas of world-wide and hemispherical extent during the progress of geologic time, designated as primary and secondary cycles. Length of time represented by curve estimated in terms of tens of millions of years. Secondary cycles are superposed on a primary cycle.

In view of the difficulty of executing a curve showing the range of the single climatic element, temperature, through the ages it would seem almost hopeless to attempt representation of all the climatic elements, frequently divergent in their intensity, as a single curve. And while it may seem desirable to represent for any region or locality the march of the element, temperature, or the march of the composite, climate, through geologic time in the form of one or more mathematical equations, yet so far this does not seem possible of accomplishment. Such equations, if formulated, must include one or more variables which would tend to minimize their value. The time will probably never come when all natural phenomena can be reduced to mathematics, even if that were desirable.

Curves as Figure 1 (top curve) may be constructed illustrating the daily, monthly, or seasonal march of temperature for a locality or a region. Such curves would also exhibit a similar uneven, arhythmic trend. The superposition of these curves upon the curve of Figure 1

would greatly complicate that curve, but by using a sufficiently large scale their accurate representation is possible. In this way the march of temperature would be faithfully portrayed, but the resulting curve in its physical aspect would differ in no essential particular from the arhythmic curve of Figure 1. (Top curve).

Since the march of temperature through geologic time is continuous, minor fluctuations of the small amplitude and brief duration just described and illustrated in Figure 1 (top curve) may be designated as quaternary cycles, the effects of which involve areas of limited extent. The temperature pulsations of areas embracing large parts of the earth, however, are to be measured in terms of longer sequence, as decades or scores of years, or even centuries, as the cold fourteenth century. The fluctuations nevertheless are aperiodic, the span of cold years differing in length from the span of warm years, and succeeding spans of cold or warm years likewise being of unequal intensity as well as of unequal duration. Figure 1 middle curve illustrates the trend of temperatures through the centuries, the pulsations of which are familiar within the historic period. The middle curve of Figure 1 differs in no essential respects from the top one of Figure 1 except that the amplitude of the pulsations is larger, their duration longer, and the temperature effects are experienced over larger areas of the earth's surface, as regions or large parts of continents. Such fluctuations in temperature may be designated as tertiary cycles.

Going back into geologic time a similar temperature fluctuation is discernible, but the pulsations recognized have been of much longer period and greater amplitude when compared with the pulsations within the historic period. Warm periods have alternated with cold periods, the warm periods continuing apparently much longer than the cold periods, so that it is customary to regard the former condition as typical of earth climate through geologic time. These major fluctuations in climate are of world-wide extent, the warm span of the cycle possessing average world temperature of 15° to 20° F. above that of to-day (59° F.), with weaker zonal and seasonal contrasts as compared with the present. The cold span of the cycle was normally of briefer duration than the warm span with world temperature 10° to 15° F. below the average temperature of the present and with marked seasonal and zonal contrasts, high temperature gradients and vigorous atmospheric circulation very similar to the condition of to-day.

There may be some question as to whether the temperature departures from the present mean for the world (59° F.) during the warm and cold periods were of the magnitude just given, but the distribution of animals and plants indicate that during the warm periods equable conditions with weakened zonal contrast have extended from the equatorial region far northward and southward, with climate more genial than the present in temperate and polar regions. During the cold periods glaciers descended to low altitudes on the uplands of the whole world, and snow and ice mantled large areas of the earth's surface outside of polar regions. The temperature of tropical regions was lowered, and animals and plants withdrew equatorward, became extinct, or developed resistance by adaptation to rigorous environmental conditions.

The major fluctuations in temperature just described are the most significant climatic features in the history of the earth. They have notably and repeatedly influenced the life of the earth, and have left the record of their duration in widespread deposits. In the effort to explain the causes of these repeated and pronounced major fluctuations much has been written, but the problem still awaits an adequate, convincing, and complete explanation. The major fluctuations in temperature during the progress of geologic time with duration to be measured in terms of millions and tens of millions of years may be designated as primary cycles. They are graphically represented in the bottom curve of Figure 1.

The primary cycles in turn are subject to long-range, irregular fluctuation. For example, during the cold periods glaciers have repeatedly advanced and retreated; thus during the "ice age" through which North America has recently passed glaciers of regional proportions accumulated and melted five successive times, the intervening interglacial epochs being of unequal duration, and some of them possibly with higher average temperature than that of the present. The duration of each of the glacial and interglacial epochs is to be measured in terms of hundreds of thousands of years. The Permo-Carboniferous glaciation of low latitudes, chiefly in the Southern Hemisphere, was likewise characterized by a succession of ice advances alternating with retreats and disappearance of the ice over large areas, indicative of fluctuating temperature and possible changes in amount and distribution of precipitation and in geographic conditions.

Although the evidence is not so conclusive, yet it suggests that the long warm periods of geologic time have likewise been cyclic with colder, but not glacial, spans of time alternating with the warmer spans. These spans also are long, to be measured in terms of tens of thousands or hundreds of thousands of years, and all of a periodic or unequal duration, succeeding cold pulsations unequal in intensity and in length, succeeding warm pulsations unequal in intensity and in length, and the cold and warm spans likewise unequal in their respecitve durations. These pulsations of temperature may be designated as secondary cycles with influence world-wide or hemispherical in extent. They are diagrammatically illustrated in Figure 1 (bottom curve) in which they have been superposed upon a major or primary cycle.

It is thus possible to differentiate four sets of cycles characteristic of the march of temperature during the known history of the earth, basing the differentiation upon the respective relative lengths and amplitudes of the cycles. The primary cycles are of greatest amplitude and longest duration with world-wide effects, the secondary cycles are of smaller amplitude and briefer duration, with world-wide or hemispherical effects, the tertiary cycles are of relatively small amplitude and brief duration geologically, familiar within the historic period, with regional effects, and the quaternary cycles, familiar within the lifetime of individuals, are of very small amplitude and of very brief duration, and of local extent. The arhythmic and irregular character of the pulsations of any one of the sets of cycles is well illustrated in the curve depicted by Doctor Marvin.

TORNADO AT VERNON, CALIF., MARCH 15, 1930

By MARION E. DICE, General Petroleum Corporation

On Saturday, March 15, a tornado of small proportions traveled northeastward from some point on the California coast through Hawthorne and parts of Los Angeles and blew itself out just north of the Vernon Refinery of the General Petroleum Corporation. It skirted the refinery property at Thirty-seventh and Santa Fe, destroyed a storage shed immediately across the street from the refinery, damaged the Southern Glass Co. plant at 2501 East Twenty-sixth Street, and ended in the river bottom south of Boyle Heights.

The storm was sufficiently close to us for interesting observation without danger.

According to newspaper accounts the tornado first reached destructive proportions at Lawndale and Hawthorne, where light structures were unroofed and trees were uprooted. It continued along a northeasterly path. From time to time the funnel lifted from the earth, so that portions of the path escaped damage. After lifting for a few moments, it attained higher angular velocities and returned to the ground. When it reached the deflecting barrier of Boyle Heights the spin was sufficiently decreased so that the tornado lifted again and did not reform. The hills of Monterey Park and the Sierra Madre Mountains probably had a large effect in destroying the instability of the air currents and checking the storm.

The path of the tornado was quite narrow. Press reports stated it to be only 60 to 70 feet. This figure amply describes it near Thirty-seventh Street, but it widened to about 250 feet just before the whirl stopped. Persons who followed the tornado by automobile gave its velocity along the path as about 15 miles per hour. The known length of the path was about 16 miles. Two persons were reported injured by falling objects. Several others were bruised by being blown violently about. There were no fatalities. Property damage was estimated at $20,000.

The attention of Vernon employees was first drawn to it about 11:40 a. m. by a whirl of débris to the southwest, accompanied by a roaring sound like that of heavy railroad traffic. One could see fragments of billboard posters, roofing paper, galvanized iron, and other loose débris in the whirl.

The center of the storm crossed Thirty-seventh Street at a point between Santa Fe Avenue and the Santa Fe Railroad. A galvanized-iron storage shed on Thirty-seventh Street in the rear of the Machinists' Tool & Supply Co.'s building exploded and was completely wrecked.

The direction of rotation, as seen from above on a horizontal plane, was counterclockwise. This is always the case in the Northern Hemisphere.

The storm was capped by a tremendous cumulus cloud which gave unmistakable evidence of large upward air currents. These general conditions persisted throughout the day and produced thunderstorms in the afternoon. The base of the general storm cloud was 2,500 to 3,000 feet above the earth, as near as could be judged by comparison with the height of surface structures. The cloud was slate gray, not much different from the under surface of the cumulo-nimbus of a rain squall or thunderstorm. While the funnel cloud was visible, the portions of the main cloud near it were seen to be in turbulence, although there was not the ominous greenish black appearance, with violent boiling and rolling, usually reported by tornado observers.

The funnel cloud was clearly defined north of Vernon. Itw s wahite, plainly visible against the dark storm cloud background. The white portion did not extend to the ground, the lower end of the whirl being marked only by flying débris. The lower end of the white portion seemed to dip suddenly lower from time to time and then to rise again. This was caused by pressure fluctuations in the center. Although the general movement of air within it was upward, sudden diminutions of pressure caused condensation to take place at lower levels and thus made visible the funnel dipping toward the earth.

If the entire whirl had been visible it probably would have resembled an hourglass, with the smallest cross section at some distance above the earth. The bottom of the visible funnel appeared noticeably smaller than the whirl of débris on the ground. This impression may have been faulty due to perspective or to the tendency for the eye to report dimensions near the earth, where comparisons are possible, as larger than the same dimensions in the air.

The diameter of the whirl of material near the glass plant was 200 to 250 feet. It was intermediate between the diameters of the two gas holders of the Southern California Gas Co., which are visible from the department of tests. These holders are 177 and 273 feet in diameter. The height to which flying material extended in the whirl was two or three times the diameter of the whirl, or roughly 600 feet.

After the tornado reached Thirty-seventh Street, where our observations began, it did not appear to move in a straight line. The vortex seemed to sway from side to side as it progressed, hesitating at times and skipping quickly at other times.

As a general rule, all the characteristics of a violent thundershower accompany the passing of a tornado. In this instance, however, no lightning was seen from Vernon at the time of the tornado. A thundershower occurred later in the afternoon. Hail and rain fell to the northwest of the path only. The usual tornado reports attribute a lurid reddish appearance to the main cloud. This color is probably due to lightning flashes within the cloud. It was not observed at Vernon. The usual reports also mention a yellow or brownish color in the bottom portion of the funnel, due to dust, with a white portion above. The dust colors were absent at Vernon because of the heavy rains of Friday night.

By watching spectators as they caught their first glimpse of the storm, one could immediately sort out the middle westerners from the native sons. Californians, most of whom had never seen a tornado, watched it with no thought of danger, while more experienced Kansans and Iowans were casting about for convenient shelters into which to dive if the whirl came closer.

Tornadoes are uncommon west of the Rocky Mountains although small waterspouts are seen on the southern California coast on an average of one or two days per year. These occasionally sweep a few miles inland, becoming tornadoes. The last previous tornado in Los Angeles was reported in 1921.

Meteorological conditions of this storm.—The weather map of 5 a. m., March 15 (not reproduced), showed three low-pressure areas controlling the weather in California. The first was centered off the coast northwest of San Francisco, the second south of Los Angeles and west of Lower California, and the third in central Nevada.

The wind at Vernon was from the east and northeast all morning. Rain had fallen during the night. The weather during the morning was unsettled, but without rain. The circulation was obviously controlled by LOW

(To face p. 324)

FIGURES 1, 2, AND 3.—A sequence of three views of the funnel cloud taken by Mr. H. B. Hensel, looking northward from the personnel department automobile park. The third view was taken just as the funnel broke up

FIGURE 1A

FIGURE 2A

FIGURES 1A, 2A, AND 3A.—A sequence of three photographs taken from the department of tests by Mr. Donald E. Dickey. These show the first and most spectacular stage of the tornado north of Vernon. The funnel disappeared after 3A was taken

FIGURE 4.—Looking north along the Santa Fe Railroad from Thirty-seventh Street. Photograph by Mr. L. F. Knox, who said the visible funnel extended almost to the ground just before the picture, but seemed to pull up quickly into the air before he could snap the shutter. The time was about 11.40 a. m.

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FIGURE 1.—Tornado funnel cloud photographed by Ira B. Blackstock about 4.30 p. m. June 2, 1929, at Hardtner, Kans.

No. 2. The circulation about LOWS 1 and 3 would produce west winds at Los Angeles, opposing those of No. 2. Evidently there was a conflict of wind systems during the morning, one bringing cold air from the desert and the other warmer, moisture-laden air from the ocean. Surface wind vanes did not indicate any reversal of direction during the morning, but one of our photographs,

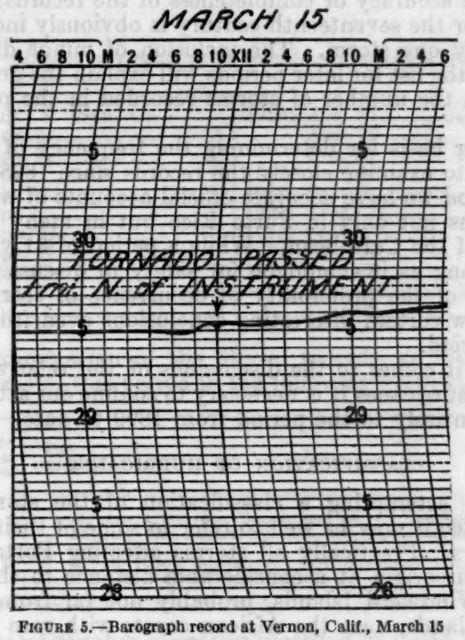

FIGURE 5.—Barograph record at Vernon, Calif., March 15

taken a few minutes after the tornado passed, showed in the cloud formation a pronounced movement upward and from west to east, as opposed to the surface wind from east to west. Apparently the tornado occurred on the wind-shift line. Perhaps the fact that surface winds did not shift was a factor in limiting the intensity of the surface whirl. The chief wind changes were aloft.

Wind and temperature conditions were conducive of upward currents, indicative of squalls and thunderstorms. The centers of all three LOWS were at very low pressures (29.4, 29.4, 29.5 inches), affording general cyclonic movements of considerable intensity.

Rain began at the Los Angeles Weather Bureau (Sixth and Main Streets) at 11:10 a. m., rain and hail at 11:23; hail stopped at 11:40, rain at 11:50. Lightning and thunder were observed. No rain or hail fell at Vernon during this time, although thunder was heard. The Vernon observations were made at a point 2.8 miles S. 33° E. from the Los Angeles Weather Bureau.

The tornado passed within a mile of the barograph at the department of tests in Vernon. Figure 5, the barograph curve showed only a weak pressure drop, indicating that the tornado was not a severe one, although the instrumental effects were of quite definite tornadic character. The barograph had been reading 29.50 inches of mercury during the rain of Friday afternoon and night and until 8:30 a. m. on Saturday. It rose slowly to 29.55 at 11 a. m. and held there until about the time of the storm, when it fell to 29.53 and then rose again to 29.55 by 12:15 p. m. The observed pressure drop of 0.02 inch, followed by an equal rise, was no greater than that due to a moving thunderstorm of the type well known in the Middle West and East. Air temperature and wind velocities were not measured at Vernon. The wind was estimated at less than 10 miles per hour outside the direct path of the tornado, where velocities of perhaps 40 or 50 miles were attained.

No rain fell in Vernon until about 3 p. m., after which intermittent rain with thunder continued until late in the evening.

REFERENCES

(1) Finley, Tornadoes, New York, 1887. Ferrel, A Popular Treatise of the Winds, New York, 1889. Although these books are old, they contain the detailed discussions of tornadoes which are the basis of standard works of the present day.
(2) Humphreys, Physics of the Air, Philadelphia, 1920.
(3) Milham, Meteorology, New York, 1925.
(4) A. J. Henry et al., Weather Forecasting in the United States, U. S. Weather Bureau, 1916.

THE HARDTNER (KANS.) TORNADO OF JUNE 2, 1929[1]

By IRA B. BLACKSTOCK

The tornado at Hardtner, Kans., was observed under very favorable conditions of light about 4:30 p. m. Sunday, June 2, 1929, and was photographed at that time. (See fig. 1.) There was no scattering of débris during the storm or afterwards other than that caused by the contact of the funnel cloud with the earth as it passed across country.

The wind came from south or perhaps a little southwest of Hardtner and then from a northeasterly or perhaps more of an easterly direction. Large hail preceded the storm by several miles and there was a light rain and a very strong rumbling noise associated with the passing of the tornado. The temperature in the morning was was 75° at 9 o'clock, 90° at noon, and 95° at 3 p. m. There was a considerable fall in the temperature. The tornado cloud from which the funnel was pendent was of a dirty dark-brown color and extended about 10 miles east-west and 1½ miles north-south. There was practically no lightning. The top of the funnel was perhaps 2 city blocks or more wide and the bottom where it touched the ground did not seem to be over 150 feet wide.

The whirling of the funnel cloud was clearly visible from the top where it joined the main cloud all the way down to where it made contact with the earth.

Little damage was done perhaps due to the fact that the storm was a dying one and its path was through comparatively thinly settled country.[2]

Two small dwelling houses were twisted partially from their foundations and a number of barns and sheds also were slightly damaged; wheat fields in the path of the tornado suffered considerable damage.

The approach of the tornado was clearly seen and I was able to make a kodak snapshot of the funnel cloud at a distance of less than a mile from its path; quite a number of others also snapped pictures of it because it was easy to do so. Almost every farm in Kansas is provided with a storm cave or cellar just outside of the dwelling house so that one can be brave and courageous with one foot on the stairway to the cave, quickly snap his or her kodak and then duck to safety. (There were several of us in the cave on the occasion of this storm.)

[1] Credit for bringing the attention of the U. S. Weather Bureau to this tornado belongs to Dr. David White, home secretary, National Academy of Sciences, Washington, D. C., who received a copy of the print reproduced as Figure 1 and brought it to the attention of the bureau. The print was used as a front cover illustration of Science News-Letter of July 19, 1930. Mr. Blackstock has furnished a report on the storm from which the text following has been condensed.—*Ed.*

[2] The cyclonic storm that gave rise to the tornado was centered over southeastern Colorado on the morning of June 2. Its normal northeastward movement was prevented by a strong area of high pressure over Lake Superior and it disappeared during June 2 over Kansas. It may be that the lack of violence displayed by the tornado was in a measure due to the disappearance of the original cyclonic storm as just stated.—*Ed.*

ON THE FREQUENCY OF HURRICANES IN THE VICINITY OF PORTO RICO[1]

By OLIVER L. FASSIG

[Weather Bureau, San Juan, Porto Rico]

How often may we expect a hurricane in the vicinity of Porto Rico?

(1) Of great intensity, such as the storm of August 8, 1899 (San Ciriaco)[2] or of September 13, 1928 (San Felipe.)[2]

(2) Of the second order of intensity, such as the storm of August 22, 1916, or of July 23, 1926.

(3) Of a mild type, such as the storm of September 10, 1921, or of August 29, 1924.

On first thought an answer to these questions may seem to be simply a matter of searching the annals of Porto Rico and noting the frequency of occurrence of storms of great violence. The problem is not so simple, however. References to storms in available historic records are often very fragmentary and very misleading. Estimates of loss of life and extent of property destroyed are contradictory, even in the case of storms of such recent occurrence as 1899 and 1928. Official records of wind velocity and of barometer readings are entirely lacking, prior to 1875.

Bulletin No. 32[3] of the United States Weather Bureau contains a list of 44 hurricanes of more or less violence occurring in the vicinity of Porto Rico from 1515 to 1899. In most cases cited there is not sufficient evidence to classify the storm on a basis of intensity.

It is only since 1898, when the United States Weather Bureau established a series of storm-warning stations in the West Indies, that we have sufficiently detailed information available about these storms to enable us to arrange them satisfactorily, in accordance with their extent and intensity.

Incomplete as the list of storms prior to 1898 is, we may safely use it to determine the distribution of storms through the year. Combining the two periods we find that hurricanes occurred in the vicinity of Porto Rico during the period from 1515 to 1929 with the following monthly frequencies:

Storm frequencies by month

June	1	September	25
July	9	October	6
August	23		

The only June hurricane recorded in a period of 400 years in the vicinity of Porto Rico occurred in 1780, and the meager description leaves us in doubt as to the character of the storm. Hence we may safely disregard June as a hurricane month. July, August, September, and October constitute the hurricane season for Porto Rico. July and October storms are of infrequent occurrence. Since 1899 we have had but two July storms (1901 and 1906) and but one in October (1916). August and September storms were of nearly equal frequency, there being 23 and 25, respectively, based upon the records for the entire period. The August and September storms as recorded in the recent period 1899–1929 show a greater divergence (6 of the former and 11 of the latter), due undoubtedly to the fact that the earlier records probably do not include storms of a milder type.

Distribution by centuries

1515–1599	10	1800–1898	21
1600–1699	1	1899–1929	20
1700–1799	12		

The frequencies for the different centuries show too great a variation to permit us to place much reliance upon the accuracy or completeness of the records. The record for the seventeenth century is obviously incorrect with only one storm. The inclusion of minor disturbances in the list for later periods will explain the great increase in the number of storms recorded in the past 31 years.

A safer basis for determining the frequency of hurricanes is to examine closely the records since 1898. For this period we have accurate official accounts of weather conditions not only in Porto Rico but in many of the islands of the Caribbean. While a period of 31 years is not as long as it should be for safety in discussing the question of the probability of occurrence of storms we may draw certain interesting conclusions even from this short period.

When it comes to the discussions of the relative violence of hurricanes it is necessary to confine our attention almost entirely to the period from 1899 to date.

CLASSIFICATION OF HURRICANES

Before attempting a classification of the storms of Porto Rico it may be well to refer to some of their characteristics. Practically all storms affecting Porto Rico have their origin at a considerable distance to the east of the Windward Islands, probably not far from Cape Verde Islands, near the African coast; with rare exceptions they enter the eastern Caribbean area fully developed. Their course varies generally between east-west and southeast-northwest.

Porto Rico is exposed only to the first or westward moving branch of the usual parabolic path of the storms. The rate of progress of the storm as a whole varies from 10 to 15 miles per hour, depending upon the rate of free movement of the trade winds which carry these storms in a westerly direction.

The island lies between latitudes 18 and 19 N. and between longitudes 66 and 67 W. and hence is in the center of the hurricane belt with its width of 40 miles exposed to the westward moving storms. The area of great devastation within a hurricane seldom extends beyond a distance of 50 miles from the center of the storm. In any well developed storm, winds of 75 miles per hour or more occur near the center. Beyond a radius of 50 miles however, the winds rapidly decrease in force. The rainfall attending these storms may extend to 150 to 200 miles from the center.

As we are considering the frequency and intensity of hurricanes in the vicinity of Porto Rico only, the classification is based upon the extent of the island covered by the central area of hurricane winds.

Class A.—Storms in which the entire Island is swept by winds exceeding 75 miles an hour.

Class B.—Storms in which hurricane winds occur over a portion of the island only.

Class C.—When the winds do not reach full hurricane force over any portion of the island.

All storms considered are assumed to be real hurricanes, but classification into groups A, B, and C depends on the distance of the center of the storm from Porto Rico. In storms of class A the center passed directly over Porto Rico attended by hurricane winds over the

[1] Reprinted with slight changes from the Porto Rico Journal of Public Health and Tropical Medicine Vol. V, No. 2, December, 1929.

[2] The Saints Days upon which the storms passed over Porto Rico.

[3] Alexander, W. H.: Hurricanes. U. S. Weather Bureau. Bul. 32, 1902.

entire island. In class B the center was not more than 50 miles distant, while in class C the center was more than 50 miles distant. Hence the importance of anticipating the exact distance of the center from any portion of the island on the approach of a hurricane.

With this statement of the basis of hurricane classification we may examine the list of storms recorded in the vicinity of Porto Rico since the historic storm of August 8, 1899.

TABLE I.—*List of hurricanes in the vicinity of Porto Rico (1899–1929)*

	Class		Class
1899: Aug. 8 (San Ciriaco)	A	1916: Aug. 22	B
Sept. 9	C	Aug. 29	C
1900, Sept 1	C	Oct. 10	B
1901, July 7	C	1917, Sept. 21	C
1906, Sept 3	C	1919, Sept. 3	C
1908, Sept. 10	C	1921, Sept. 10	C
Sept. 27	C	1922, Sept. 17	C
1909, Aug. 22	B	1924, Aug. 29	C
1910, Sept. 6	B	1926, July 23	B
1915, Aug. 11	B	1928, Sept. 13 (San Felipe)	A

On examination of the official records we may place the storms of this period in the following groups:

Class	Number of storms	Percentage	Dates
A	2	10	Aug. 8, 1899 (San Ciriaco); Sept. 13, 1928 (San Felipe).
B	6	30	July, 1926; August, 1909, 1915, 1916; September, 1910; October, 1916.
C	12	60	July, 1901; August, 1916, 1924; September, 1899, 1900, 1906, (2) 1908, 1917, 1919, 1922, 1921.

The total number of storms recorded in Porto Rico for the 31 years from 1899 to date is 20. As already shown in the list of storms prior to 1899 the hurricane months are July, August, September, and October. Class A shows only two hurricanes in 31 years with an interval of 30 years; class B shows 6, with an average interval of 5 years, and class C shows 12, with an average interval of 2½ years. The distribution of the storms through the period is not at all even, however, as there are 2 periods of 4 consecutive years and 6 periods of 1 year without a storm of any class. There was but 1 storm in the month of October and only 2 in the month of July, confirming the common impression that the months of August and September constitute the real hurricane season in the vicinity of Porto Rico. Six storms are credited to August and 11 to September, but 9 of the 11 September storms were of the mild type, or class C.

As storms of class A were of such infrequent occurrence from 1899 to 1929 an effort was made to extend the period for this class backward to the beginning of the nineteenth century. This may safely be done as storms of such violence would certainly be noted in any local chronicle of hurricanes. In looking over Alexander's list of hurricanes from 1800 to 1899 we find only two additional storms which seem to merit a place with San Ciriaco and San Felipe II, namely, Santa Ana (July 26, 1825) and San Narciso (October 29, 1867). Incidentally, San Narciso is the only storm recorded after the middle of October in a period of over 400 years. Los Angeles (August 2, 1837), Santa Elena (August 18, 1851), and San Felipe I (September 13, 1876), which are frequently quoted as historic storms, seem rather to have been of class B, so far as extent of damage in Porto Rico is concerned. The addition of these two storms of the nineteenth century will give us four storms of class A in a period of 130 years, with an average interval of 31 years.

As storms of class C are on the whole beneficial, owing to the value of the rains which they bring and the comparatively small property losses, we may disregard this class as a source of personal danger, eliminating the element of fear from 60 per cent of the total number of Porto Rican hurricanes.

Storms of class B are likewise attended by beneficial rains; but such benefits may or may not be overshadowed by heavy local property losses.

Storms of class A are a calamity and are responsible for the universal dread which seems to be inseparably connected with the word hurricane throughout the world. Hurricanes of the severest type, if their centers are more than 50 miles distant, are more likely to be beneficial than harmful, as winds exceeding 75 miles an hour seldom extend beyond this distance from the center.

Reviewing the statistics in the above tables and including class A hurricanes of the nineteenth century, we have the following hurricane frequencies for Porto Rico and vicinity:

Class	Number of storms	Period of years
A	4	130
B	6	31
C	12	31

While we may not be justified in concluding that these frequencies and proportions will hold good in the future we may say that the probabilities are in favor of the occurrence of 1 storm of class A, 6 storms of class B, and 12 storms of class C in the next generation. Even this broad statement may have some practical value in esti mating probable losses to property and crops and in determining insurance rates.

THUNDER AND LIGHTNING IN THE SOUTH PACIFIC OCEAN

By ANDREW THOMSON

[Apia Observatory, Apia, Samoa]

In the South Seas and Southern Pacific Ocean violent thunderstorms are not of frequent occurrence. In my nine years' residence in Samoa I have only experienced 2 electrical storms which compared in intensity with 5 or 6 per annum in southern Ontario and New England. Lightning, however, often occurs on the open ocean, but is probably most frequent in the vicinity of the island groups which dot the western half of the South Pacific. The research yacht *Carnegie* observed thunder or lightning on 27 of the 139 days she has spent during her fourth, fifth, and sixth cruises (1) within the Tropics of the South Pacific Ocean.

Continuous records of thunderstorms are available from Apia, Samoa; Suva, Fiji; Nauru; and Rarotonga. Other records with less sharp distinctions drawn between thunder and lightning have been obtained from Papeete, Tahiti; Nassau; and Niue Islands. Discrepancies in the records show that observers used widely differing ideas of a thunderstorm, the occurrence of lightning being frequently not recorded.

In Table 1 is given the number of days thunder was recorded at the most reliable stations.

TABLE 1.—*Monthly variation of days with thunder at stations in the South Pacific Ocean*

[The mean has been derived only from those stations in the trade-wind area marked with asterisks]

	Lat.	Long.	Years	January	February	March	April	May	June	July	August	September	October	November	December	Total
	°	°														
Apia	13.8 S	171.8 W	1923–1929	2.8	2.4	2.2	3.4	1.6	1.6	0.8	1.0	1.9	4.4	6.2	4.8	32.6
Apia (2)	13.8 S	171.8 W	1891–1929	4.1	3.3	4.4	3.7	2.5	1.7	.7	.5	1.2	2.8	4.7	5.2	34.3
Suva (3)	18.2 S	178.5 E	1923–1929*	2.4	2.9	3.3	3.3	1.0	.9	.7	.4	.3	1.0	1.7	2.4	20.3
Chatham Islands (4)	43.9 S	170.7 W	26 years	1.2	.9	.4	.6	.9	.6	.8	.5	.5	.5	.5	1.0	8.2
Rarotonga (5)	21.2 S	159.2 W	10 years	2.2	1.9	1.9	.9	1.1	.7	.7	.5	.5	.9	.8	1.0	13.1
Batavia (6)	6.2 S	106.8 E		13.3	12.5	14.4	14.0	11.0	8.0	5.9	5.0	7.4	12.4	16.0	13.2	133.1
Nauru (5)	.4 S	166.9 W	6 years*	.7	1.7	.3	.2	.5	1.0	1.2	.2	.5	.2	.2	.2	6.2
Mean				2.3	2.4	2.5	2.0	1.3	1.1	.8	.4	.6	1.2	1.8	2.2	18.4

TABLE 2.—*Monthly variation of days with either thunder or lightning*

	Lat.	Long.	Years	January	February	March	April	May	June	July	August	September	October	November	December	Total
Apia	13.8 S	171.8 W	1925–1929	5.4	4.6	5.2	7.8	4.6	5.4	1.4	3.4	4.0	8.6	9.6	9.2	69.2
Do	13.8 S	171.8 W	1891–1907	5.6	4.2	5.7	5.2	3.1	1.8	1.0	.7	1.4	5.1	4.9	5.6	44.3
Suva	18.2 S	178.5 E	1927–1929	2.7	2.7	4.7	3.0	.3	2.7	-------	1.0	.7	2.0	3.3	7.0	30.1
Papeete	17.5 S	149.5 W	1925–1929	2.0	2.4	3.5	1.2	.4	.2	.4	.0	.0	1.2	.4	2.0	13.7
Niue	19.0 S	169.9 W	1926–1929	.8	2.2	3.8	1.0	.3	.0	.7	.7	1.7	1.3	.0	4.0	16.5
Nassau	11.6 S	165.4 W	1928–29	.5	1.0	2.0	2.7	1.3	.5	1.5	-------	1.0	2.0	2.5	-------	15.0
Rarotonga	21.2 S	159.2 W	1899–1909	3.1	2.9	3.3	1.5	2.1	1.0	1.3	.8	.9	1.4	1.2	1.0	20.5
Nauru	0.4 S	166.9 W	1893–1901	1.0	2.0	1.0	.6	1.6	2.4	1.0	1.5	1.0	1.1	1.3	2.1	16.6
Mean				2.2	2.5	3.4	2.2	1.3	1.2	.8	.7	.9	2.0	1.9	3.1	28.2

Careful distinction must be made to note exactly the phenomena the observer has recorded. Thus, at Suva during the three years 1927–1929 atmospheric electric phenomena were recorded on 90 days, out of which lightning only was observed 82 days and thunder only on 62 days. When days with either lightning or thunder are included (Table 2) the figures are much altered from those given in Table 1.

Owing to the frequency and regularity of heat or summer lightning, observers almost invariably fail to record it. Often only one or two clouds are for an instant illumined by a glow. The lightning flashes pass from cloud to cloud, but rarely go down to the surface of the ocean. Some observers in Samoa have (7) believed the lightning to occur most frequent during the daytime over the mountain peaks and in the evening out to sea. During March and April, 1930, lightning has been persistently, both afternoon and evening, more common out to sea. Thunder rarely accompanies these displays of lightning. Over 100 flashes have been seen in three hours without a single peal of thunder having been heard.

In the south seas the yearly variation of days with thunder has a single flat maximum from December to March, with a pronounced minimum in August and September. The rainy season, in which at Apia 74 per cent of the rainfall occurs, covers the period November to April. During this period the southeast trade winds blow intermittently and are often interrupted by northeast and northwest winds and by calms. At Apia lightning does not show the pronounced minimum in the dry season from May to October that occurs with thunder. There are indications of two maxima in April and October, months that mark the setting in and cessation of the trade winds.

DIURNAL VARIATION OF THUNDER

An unusually careful record of the exact hour of occurrence of thunder and lightning was begun by Dr. B. Funk at Apia in January, 1891, and continued, except for absences amounting to one and one-half years, to December, 1899. During this period the time of thunder was recorded on 235 occasions to the nearest quarter of an hour and on 41 entries to a fairly definite time as "during the night," "toward morning," or "very early." After these 41 entries have been allocated the occurrence of thunder for each period of two hours is given in Table 3. The great difficulty has always been to obtain complete thunder records during the night hours from, say, 11 p. m. to 6 a. m. However, Doctor Funk had unusual opportunities for securing data, and his observations show meticulous care in noting whether thunder or lightning occurred.

TABLE 3.—*Average hourly frequency of thunder, negative electrical potential of the atmosphere, and rainfall at Apia, Samoa*

	0–2	2–4	4–6	6–8	8–10	10–12	12–14	14–16	16–18	18–20	20–22	22–24
Average number of hourly periods thunder was recorded per annum	1.3	1.4	1.1	1.1	0.9	2.1	2.1	2.7	1.8	2.0	2.4	1.4
Average number of hourly periods negative electrical potential of atmosphere was recorded per annum	3.3	3.3	3.2	2.8	2.8	3.0	4.2	4.0	3.6	3.2	3.4	3.6
Mean rainfall per hour in tenths of millimeters	3.2	3.4	3.1	2.7	2.4	2.4	2.7	3.9	3.9	3.7	3.4	3.0

G. R. Wait (9) has shown that there is probably a close relationship between the occurrence of thunderstorms and of negative electrical potential of the atmosphere. Since records of electrical potential are obtained by a self-registering electrometer the results are entirely free from the the human element. In three years' records from 1925 to 1927 the occurrence of negative electrical potential for the hours from midnight to 4 a. m. was slightly below the mean for the day. In view of the close association of negative electricity with thunderstorms, the atmospheric electric data confirms Doctor Funk's observations that thunder occurs less frequently from midnight to 9 a. m. than during the rest of the day. The minimum for the 24 hours occurs from 9 a. m. to 10 a. m. The frequency of thunder increases sharply after 10 a. m. and reaches a maximum during the afternoon from 1 p. m. to 4 p. m. A pronounced but short period of comparative rarity of thunder extends from 4 p. m. to 7 p. m., thunder during this period being one-third less frequent than during the afternoon and evening hours. From 7 p. m. to 11 p. m. thunder was recorded almost but not quite as often as in the early afternoon. The afternoon maxima occurs at the same hours as the heaviest and most frequent rainfalls. The evening maximum would appear to be caused by convection currents in the lower stratum of air. Lightning occurs three times as frequently from 7 p. m. to 10 p. m. as at any other period of the day.

According to a frequently quoted article by W. Meinardius (10) the period of maximum thunderstorms over the ocean occurs from midnight to 4 a. m. Conditions at Samoa are probably typical of those prevailing on the open ocean in the trade-wind belt of the South Pacific, and for this area the results are at variance with those stated by Meinardius.

Apart from the difficulty of securing ships' logs, it is not easy to determine from them the definite occurrence of thunder and lightning on the open ocean. The only useful records I have obtained were 221 days' observations (Table 3) taken by the nonmagnetic yacht *Carnegie* while cruising mostly far from land between the Equator and the Tropic of Capricorn (1). In the western half of the tropical Pacific, thunder or lightning was recorded on 33.8 per cent of the days, while in the eastern half on 3.1 per cent of the days. This high frequency indicated clearly that electrical storms are as common at sea as in the vicinity of small tropical islands. The excess over the total recorded by the island observers arises largely from the continuous watch kept on the *Carnegie* during the night hours.

TABLE 4.—*Frequency of thunder and lightning on open ocean within South Tropic Zone, from log of yacht "Carnegie," 1915–1921*

	Days of observations	Days of lightning only	Days of thunder with or without lightning	Percentage of days with electrical storms
Western Pacific, west of longitude 140° W.	74	16	9	33.8
Eastern Pacific, east of longtitude 140° W.	15	1	1	3.1
Total	139	17	10	19.4

Geographical distribution.—Although the data are scanty, it is apparent that thunderstorms are much more frequent

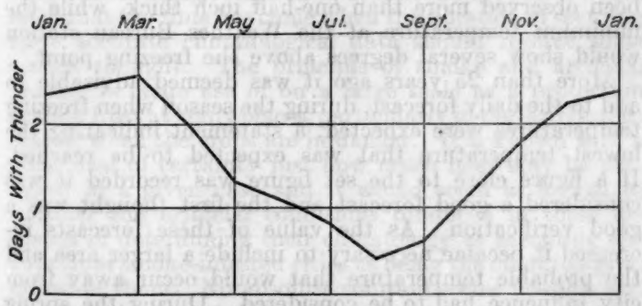

FIGURE 1.—Average number of days with thunder per month at four stations in the southwest Pacific

in the western Pacific than in the central or the eastern Pacific. According to reports from Papeete, Tahiti, lightning has been observed only about 16.6 days per annum, compared with 56.8 per annum at Apia. The *Carnegie* has recorded thunder and lightning ten times as frequently in the Southern Pacific west of the one hundred and fortieth west meridian as east of this meridian.

In the eastern Pacific the trade winds blow more strongly than in the western Pacific. Cyclones are very rare east of the one hundred and fortieth west meridian. The southeast wind circulation probably reaching greater heights than in the western Pacific and the uniformity and considerable velocity of the air stratum up to 7 or 8 km. are probably effective factors in reducing the number of thunderstorms east of the one hundred and fortieth meridian.

Local causes of thunderstorms.—Thunderstorms occur most frequently when strong vertical air currents are set up by a high temperature lapse rate in the rain-cloud stratum of the atmosphere. The conditions when either the vertical currents are sufficiently strong or the temperature lapse rate sufficiently high are as follows:

(1) *Tropical cyclones.*—Especially in low latitudes before the passage of a few tropical cyclones violent thunderstorms occur. In a cyclone on December 25, 1926, violent thunderstorms accompanied the passage of the center over the Union group, latitude 8° S., but when passing over eastern Samoa, latitude 16° S., no thunder occurred.

(2) *The "clash of the northeast and southeast trades"* (11).—Instead of an extensive doldrum area, as in the Atlantic, the northeast and southeast trades in the Pacific run rather abruptly into one another. Along the line of meeting there must be turbulence, with strong upward vertical currents between the conflicting air masses. The line of meeting varies with the season from probably 10° N. to 10° S. latitude.

(3) *The mixing of the cold southwest countertrades with the surface southeast trades which they overrun.*—The height which the trades reach varies from nothing up to 3 or 4 km. Pilot-balloon observations have in general shown a very thin stratum between the southeast trades and the countertrades. Now when the air layers over the ocean are warmed by insolation, the evenness of the dividing surface is interfered with and air masses with considerable temperature differences are brought in contact with one another. After the sun goes down the most rapid temperature fall for 60 minutes occurs at the surface between either 5:30 p. m. and 7 p. m., depending on latitude. At levels 1 to 4 km. the rate of fall would probably be delayed for some hours.

(4) An unusual cause for lightning in Samoa in former years was the active volcano Matavanu, in Savai'i.

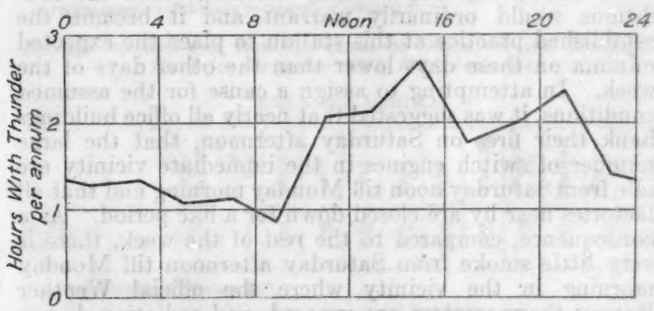

FIGURE 2.—Hourly frequency of thunder at Apia, Samoa. Maximum at 15h is due to rain and at 21h to convection currents from high lapse rates after sunset

The strong convection currents rising from the crater and from the fields of hot lava produced cumulus clouds, which were frequently illumined by flashes of lightning.

Losses from lightning.—In nine years in the Samoa and Fiji groups, with a total population of 200,000, two people have been reported struck by lightning and killed. Occasionally the tops of the tall coconut palm trees are shattered. In February, 1922, a schooner in Apia Harbor was struck by lightning, her foremast was splintered, and the direction of her compass needle altered by 20°. Property damage from lightning is almost neglible in the islands of the South Pacific.

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CITY SMOKE AND HEAT EFFECTS ON MINIMUM TEMPERATURES[1]

By FRED L. DISTERDICK

[Weather Bureau, Des Moines, Iowa]

One of the most persistent problems that a Weather Bureau official is required to solve is to give a satisfactory explanation of the discrepancy existing between the usual minimum temperatures reported from Weather Bureau stations and those reported by reliable instruments exposed in the same locality but under natural conditions, or under conditions that are as near natural as it is possible to find. This question is by no means a new one and it came up as often 25 years ago as it does at the present time. The answer usually given is city influence, which may be one or a combination of several causes, the principal one of which is smoke and artificial heat, accompanied by very little wind. That the artificial conditions existing in all cities have a marked influence on the temperature of the air is a fact recognized by every one, but few realize how great the discrepancy may be under favorable conditions. Most discussions of this subject treat of the average conditions and the exceptional cases are not brought to light. Should the smoke evil be remedied to any great extent it is believed that the city influence as affecting the daily minima would be very much lessened.

Several years ago it was observed at Des Moines that there was a pronounced tendency for the minima to be lower on Sunday and Monday mornings than the conditions would ordinarily warrant and it became the established practice at this station to place the expected minima on these days lower than the other days of the week. In attempting to assign a cause for the assumed conditions, it was suggested that nearly all office buildings bank their fires on Saturday afternoon, that the large number of switch engines in the immediate vicinity are idle from Saturday noon till Monday morning and that all factories near by are closed down for a like period. As a consequence, compared to the rest of the week, there is very little smoke from Saturday afternoon till Monday morning in the vicinity where the official Weather Bureau thermometers are exposed, and radiation during this period is very little hindered.

In order to verify this assumption actual conditions were investigated for a period of 20 years during the months in which minimum temperatures were forecast. It developed that the minima for Sunday and Monday averaged below the minima for the several months considerably more than half the number of times, and the mean for these two days was less than any combination of two days or single days. This condition would be a natural sequence of the lessened smoke and less artificial heat, and radiation would be possible on Sunday and also on Monday before new fires are kindled.

In dealing with exceptional cases it had been the general policy, when great discrepancies were brought to notice, to be skeptical of the reports or condemn the instruments with which the comparisons were made. A casual study of climatological data does not reveal the exceptional cases which are constantly occurring. The mean temperature of Weather Bureau stations and cooperative stations does not differ materially, but in a State where the general contour is such as Iowa, the regular Weather Bureau stations always show higher mean values and considerably higher mean minima. This situation is recognized by the Iowa Weather and Crop Bureau in its study of the relation that temperature bears to the development of crops and in all the growing season it is necessary to reduce the values represented by the regular Weather Bureau stations at times more than one degree, to harmonize with open exposures where the influence of artificial conditions is negligible. Also in determining the length of the growing season, it has been found necessary to exclude the data from the regular Weather Bureau stations and a number of the larger cooperative stations because the city influence as affecting plant growth is not given proper consideration. This situation is apparent by the examination of a frost table showing the length of a growing season.

Where it is possible to have daily contact where there is no city influence, the discrepancies, as revealed by instruments, are easily verified by the observation of natural phenomena. Many times during the last 10 years it has been possible both to note the instrumental discrepancies and also to observe the contrasts as revealed by the different effects in near-by places. During the last five years it has been possible to make observations under the most favorable comparative conditions. Every spring and fall it is a common occurrence to observe the ground in the open country frozen at times to a depth of more than 1 inch and ice on small pools has been observed more than one-half inch thick, while the minimum temperature at the Weather Bureau station would show several degrees above the freezing point.

More than 25 years ago it was deemed advisable to add to the daily forecast, during the season when freezing temperatures were expected, a statement indicating the lowest temperature that was expected to be reached. If a figure close to the set figure was recorded it was considered a good forecast and the first thought was a good verification. As the value of these forecasts increased it became necessary to include a larger area and the probable temperature that would occur away from city influence had to be considered. During the spring and fall truck growers are more concerned as to how low the temperature will go in their gardens than what the lowest temperature at the city Weather Bureau office might be. This fact was strikingly demonstrated several years ago when a minimum temperature of 35° was recorded at the Weather Bureau office and some of the outlying portions of the city reported a light frost, where conditions favored. As is usual, inquiry was made and conflicting reports were received as to the amount of frost damage. Some reports were that there had been no damage and one report was that everything had been killed. This report was doubted and the party making the report was considered as a pessimist and had not complete verification been secured this occasion would have passed with no further comment. However, late in the afternoon in question, in crossing a ravine through which a small stream flowed, a small pool was discovered that was still completely covered with ice, thick enough to withstand the thrust of a moderate-sized stone. This condition did not seem possible and the incidents in connection have resulted in a policy at Des Moines to consider more what the temperature might reach in a locality where damage from a freeze would result than that which may be recorded at the location of a Weather Bureau station. From a close contact with many people that are subject to frost

[1] Presented before American Meteorological Society, Des Moines, Iowa, Dec. 28, 1929.

damage it is well established that it often happens that there is very little damage in areas in the path of a light wind carrying smoke and serious damage will result in other areas not so protected. The effect of a smoke protection can be easily observed every year if the trouble is taken to visit different areas in the same vicinity. Directly west of Des Moines is a large open area more than one-half mile wide. In this area the effects of frost are observed early and there is never any smoke to ward off an injury in a critical condition. Rather early during September, 1929, a frost occurred that killed practically everything in the unprotected area. In advancing eastward the extreme edge of the city showed only traces of frost and as the city was penetrated even the most tender vegetation was not injured in the least and continued to thrive for more than a month after areas immediately adjoining were entirely without vitality.

In order to obtain positive information, reliable instruments were exposed for a time several years ago, to see just how much temperature readings in the open country and the city exposure differed, the exposures being less than 5 miles apart. It was disclosed that when conditions were favorable for radiation in the country and the city was covered with a smoke blanket, the readings were never less than 5°, most of the time they were 10°, or more, and on one occasion a difference of 17° was noted, ranging from 35° at the country exposure to 52° at the Weather Bureau office. A great deal of the climatological data that is being compiled is, at best faulty, and it would seem that the time has come when the question of securing more accurate climatological data should receive some serious thought. The principle of smoke and artificial heating is made use of on a large scale as a protection against frost at many places, particularly in the far Western States, when the crops are in danger. It is known with a great deal of certainty just how much heat may be produced in a given case and it would seem as logical to consider the artificial conditions produced in these orchards in determining their climatology as accepting the data from smoke-infested cities as being the climatological record of them. No absolute solution seems possible but it is thought that stations at, or near, air ports would offer the best solution. The situation complained of in the larger cities is gradually being felt more and more at a large number of cooperative stations. There are, however, a few cooperative stations with which comparison can be made with Weather Bureau stations that are troubled by smoke. The cooperative stations are as near natural as is possible to find anywhere. Each cooperative station is compared with the nearest regular Weather Bureau station. The average absolute minima for each month was taken and the city influence on the minima is apparent at once.

Table showing extreme minima at Weather Bureau stations and selected cooperative stations, period 1925–1928, inclusive

	January	February	March	April	May	June	July	August	September	October	November	December
Decorah	−17	−8	2	15	30	37	44	43	30	14	8	−16
Dubuque	−11	1	8	21	38	46	52	51	37	24	14	−8
Average monthly difference in extreme minima, 7.7°.												
Davenport	−9	7	9	24	37	47	52	52	38	24	14	−6
Sigourney	11	5	8	22	35	45	50	50	34	20	11	7
Average monthly difference in extreme minima, 2.2°.												
Des Moines	−7	1	11	28	37	48	55	52	37	23	12	−6
Winterset	−13	−1	6	20	28	41	47	45	32	17	8	−9
Average monthly difference in extreme minima, 5.8°.												
Omaha	−7	4	13	27	40	51	57	54	39	26	14	−4
Glenwood	−9	3	10	24	34	46	51	46	34	20	9	−5
Average monthly difference in extreme minima, 4.2°.												

Average minima and monthly means at Davenport and Davenport No. 2 for the period 1924–1928, inclusive

EXTREME MINIMA

	January	February	March	April	May	June	July	August	September	October	November	December
Davenport	−11	7	10	25	39	48	53	54	39	27	12	−7
Davenport No. 2	−13	5	8	23	34	45	48	49	35	23	9	−11
Average monthly difference, 3.4°.												

AVERAGE MONTHLY MEANS

Davenport [1]	22.9	31.0	37.7	50.1	60.4	68.4	74.6	73.2	65.4	53.9	39.2	24.5
Davenport No. 2 [2]	23.0	31.2	38.2	50.8	60.9	68.3	74.6	73.2	65.8	53.6	39.5	24.3

[1] Annual, 50.1. [2] Annual, 50.3.

THUNDERSTORM TOP KNOTS

By CHAS. F. BROOKS

[Clark University, Worcester, Mass.]

A perfectly formed cumulo-nimbus cloud housing a small but energetic thunderstorm passed within hearing distance south of Greenwich, Conn., the evening of July 11, 1930. At the time of its best development, 7:15–7:25 p. m., eastern standard time the heavy vertical mass of the thunderstorm was probably 10 km.[1] wide from east to west. The outspreading top sheet of heavy mammato-alto-stratus extended about 3 km. on either side. The convective air, most active in the front and in the rear portions of the south-eastward advancing storm and the outspreading top, was more or less a double affair spreading from these two sections. The vertical thickness of the top sheet was of the order of 1½ km., and the height of the top at least 6 km.

[1] All dimensions are based on rough angular measurements made from an elevation of about 100 m. and 4 km. from Long Island Sound, at Greenwich, Conn.

Above the western trunk of active convection a cumulus knob would appear rather rapidly, grow upward to a height of ½–1km. above the level of the top, then fall back, the complete process taking from 3 to 5 minutes. While the top knot was growing lightning was visible in it every 3 to 15 seconds, but when it was falling back lightning was less frequent, and was of the order of one-half minute to a minute. Lightning in the trunk below the top knot was still more frequent.

As a particularly large knob at 8 p. m., eastern standard time, fell back into the mass of the top sheet, great mammato-cumulus forms appeared on the under surface of the top sheet. These mammato forms were about as large as the top knob itself had been, and were evidently from the air which had come from the upper protuberance and which was now falling back and spreading out. So

strong was the convection that apparently the upward moving air was carried considerably beyond the level of equilibrium. It would soon descend and spread out around the column of rising air. The descent produced not only the mammato-cumulus forms, which in this connection were unusually large, but also certain reactions in the top of the cloud sheet near by. Rain began at 6:15 p. m. with some electric display and continued as a moderate shower for 35 minutes with a light wind. About 6:45 p. m. thunder became loud and close and a scroll of heavy dark cloud appeared rolling down from the northwest. Excessive rain began at 6:50 and lasted 25 minutes. Small hail, about the size of peas, fell from 6:50 to 6:53 and the lightning became severe. The large hail fell from 8:05 to 8:10. Melon and cucumber leaves were cut in some cases with nearly round holes. Path of storm northwest-southeast, last thunder heard southeast about 7:40.

Two humps appeared on each side of the falling center, about ½ to 1 km. from it. The hump on the east grew to a new knob and then fell back to a level. This rise and fall took about five minutes.

Another knob grew, but still farther east, and fell back. Then still another arose immediately west of this position. This last knob was about 1 km. wide and ⅓–½ km. high. This formation of protuberances in one place and then another, which seemed to be chiefly the result of the oscillation following the first large one, occupied a period of 25 minutes.

Thereafter, the storm had so decreased in intensity with the oncoming of night and had moved so far away that no further action was seen.

Intense thunder and hailstorm at Bridgehampton, Long Island.—About 50 miles farther east another small local storm struck Bridgehampton, on Long Island, at this time. Intense local convection was evidently the order of the evening. Ernest S. Clowes, writing from that place, said it was one of the most severe he had seen in several years' residence there. The following is from his letter, with times changed from daylight saving to eastern standard.

> Its distinguishing feature was hail, always a great rarity here, which fell for about five minutes, the stones mostly measuring up to ¼ inch to 1 inch in thickness, the lower figure being more common. Some jagged pieces of ice fell, one of which was reported as being 2 inches long, the measurement being made by ruler soon after the fall.

NOTES, ABSTRACTS, AND REVIEWS

Extreme July weather indicates August weather.—Five times during the last 58 years in Iowa the State mean temperature for July has been 4° or more above normal, and in every case the mean temperature of August has been above normal; also there have been 3 cases when the July mean was 4° or more below normal and in each case the August mean was below normal, so extreme July temperatures have been followed by the same tendency in August 100 per cent of the time.

As to rainfall, there have been 8 cases in 58 years when the State average rainfall for July was 2 inches or more above normal and in 6 of the 8 cases, or 75 per cent, the average rainfall of the following August was above normal; also there were 6 cases when the average rainfall of July was 2 inches or more below normal and in 5 out of the 6 cases, or 83 per cent, the average rainfall of the following August was below normal.

Briefly, there seems to be a well-marked tendency for abnormal Iowa weather in July to perpetuate itself through August. In other Corn Belt States this weather sequence is not so well defined, though Missouri shows a tendency in that direction.—*C. D. R.*

Iowa July mean temperatures 4° or more from normal (8 cases) and average rainfall 2 inches or more from normal (14 cases) in 58 years, 1873–1930; and departures from normal in the following August

Temperature			Rainfall		
Year	July	Aug.	Year	July	Aug.
	°	°		*Inches*	*Inches*
1874	+4.1	+2.6	1875	+2.22	+0.60
1901	+8.7	+2.1	1876	+2.32	+1.71
1916	+6.0	+2.3	1896	+3.07	+.08
1921	+4.2	+.4	1900	+2.32	+1.21
1930	+4.2	+2.7	1902	+4.84	+3.14
1882	−4.6	−.2	1907	+3.44	+.89
1891	−5.2	−2.6	1915	+4.49	−.63
1915	−4.2	−5.8	1922	+2.48	−.38
			1886	−3.33	−1.42
			1894	−3.20	−1.86
			1913	−2.01	−.76
			1916	−2.05	−.86
			1923	−2.08	+1.98
			1930	−2.34	−1.02

Pleistocene of northern Kentucky and other papers.—This volume, put out by Dr. W. R. Jillson, State geologist of Kentucky, contains contributions by Frank Leverett on The Pleistocene of Northern Kentucky; The Climate of Kentucky, by S. S. Visher; Geology of the Southern part of the Dawson Triangle, by A. H. Sutton; The Cretaceous Deposits of Trigg, Lyon, and Livingston Counties of Kentucky, by J. K. Roberts; and the Geology and Physiography of the Mammoth Cave National Park. The preface is by the late T. C. Chamberlin.

Kentucky's position near the southern border of the glacial drift makes a study of the distribution of scattered bowlders and other evidence of glacial action beyond the border of continuous drift of special interest to students of the glacial history of our continent.

The chapter on climate by Dr. S. S. Visher covers 86 pages and is fully illustrated by 109 maps and diagrams. The statistical presentation is based on the records of 72 stations well distributed throughout the State for the period from the beginning of observations to 1922, inclusive. The length of record varies, therefore, from 63 at Lexington to 5 at Lynnville; the great majority of records, however, are more than 10 years in length.

Table No. 3 gives statistics of irregularities in the occurrence of precipitation. The following is abstracted from that table: Number of stations used, 72. The wettest year in Kentucky, as determined by the record of individual stations, was 1890, with 11 stations, or but 15 per cent of the total so reporting; the next wettest was 1919, with 14 per cent. The driest year was 1904, with 24 stations, or 33 per cent of the total, so reporting; the next driest was 1901, a year characterized by great heat and dryness in the great interior valleys. That year had but 12 stations, or 14 per cent of the total reporting the greatest drought of record.

The extremely local character of rainfall distribution may be realized when it is considered that for the 40-year period 1883–1922 one or more stations experienced the greatest rainfall in the life of the station in 25 of the 40 years, or in 62 per cent of the years—that is to say, some 1 of the 72 stations recorded the greatest rainfall during its life in one of the years considered and only 11 of the stations recorded their heaviest precipitation in the same year.

Dry years, as is well known, occur with more frequency than wet ones, as illustrated by the number of stations,

24, that reported great dryness in 1904 and 1901. A comparison with the great drought of 1930 is, of course, not yet possible.—*A. J. H.*

The diurnal variation of the rainfall at Paris [1]—The diurnal variation of the rainfall has, until now, been studied very little in France. It is interesting from a theoretical point of view and also for purposes of weather forecasting.

The object of this note is to set forth the principal results of the discussion of 20 years of observations made at the Observatory of Montsouris from 1907 to 1926. The data to be utilized are:

1. The number of times it was raining at 3^h, 6^h, 9^h, . . . 24^h.
2. The duration of the rainfall from 0^h to 3^h, from 3^h to 6^h, from 6^h to 9^h, . . . from 21^h to 24^h.
3. The depth of water collected.
4. The number of times when it was raining within these same intervals of time.

From the numbers of times of rainfall at the different hours one deduces immediately the corresponding probabilities of rainfall, which are indicated in the following table.

Probability of rainfall at the different hours (in thousandths)

	3^h	6^h	9^h	12^h	15^h	18^h	21^h	24^h	Mean
Year	65	69	56	57	60	65	61	53	61
Oct.–Mar.	82	88	76	74	77	81	74	66	77
Apr.–Sept.	48	49	36	39	43	50	48	40	44
Wind W–N	81	81	52	56	49	51	49	42	58
Wind N–E	32	32	29	26	29	26	28	22	28
Wind E–S	41	45	44	43	57	70	65	59	53
Wind S–W	84	93	82	84	93	105	96	84	90

The mean diurnal variation, in winter as in summer, exhibits, as we already know, two maxima and two minima; but if the directions of the wind are noted, which to our knowledge has not been done, we see that this double oscillation is due to the blending of two distinct types of variation.

The diurnal variations relating to winds of west to north and of north to east are much alike; they are characterized by the probability of rain of relatively great amount between 3^h and 6^h, and of small amount the rest of the time, with no indication of a secondary maximum in the afternoon.

For the winds from east to south and south to west the diurnal variations are still more alike, and entirely different from the preceding ones; the probability of rain is great between noon and midnight and small between midnight and noon, with a very secondary relative maximum about 6^h.

The mean duration of the rainfall in each 3-hour interval being proportional to the mean probability of the rainfall in the same interval, the studies of the duration served only to confirm the above results; we are not discussing them here.

By dividing the amount of water collected by the duration of the downpour, the intensity of the rainfall has been obtained. The diurnal variation in this element has only one maximum and one minimum and gives about the same result for each wind direction.

Furthermore, taking the relation of the duration to the number of occasions of rainfall, we have a measure of the tendency of the rainfall to persist. The diurnal variation of this ratio has, like the others, a simple oscillation independent of the wind direction. It is almost inverse of that of the intensity. For lack of space we can not give, for each of these elements, more than the mean annual variation.

	0^h 3^h	3^h–6^h	6^h–9^h	9^h–12^h	12^h–15^h	15^h–18^h	18^h–21^h	21^h–24^h
Intensity of rainfall in hundredths of millimeters at the hour: Year	97	90	92	107	145	137	115	96
Degree of persistence of rainfall in hundredths of hours for times of rainfall: Year	119	122	112	96	89	91	107	115
Depth of rainfall in thousands of the total for the 24 hours: Year	108	113	112	112	155	165	132	103
Oct.–Mar.	120	122	126	117	137	143	123	112
Apr.–Sept.	96	104	96	106	174	188	143	93
Winds W–N	161	143	123	112	143	128	111	79
Winds N–E	95	110	105	109	145	158	133	144
Winds E–S	57	70	103	79	165	207	188	131
Winds S–W	91	105	107	119	161	179	135	103

When, for the eight 3-hour intervals, the mean probability of rainfall, its intensity, and degree of persistence are known, it is possible to deduce the proportion of rain collected and the probability of a fall of rain within each interval. The diurnal variations of these two elements have, like that of the probability of rain at the different hours, a form differing according to the direction of the wind.

These results prove that the diurnal variation of rainfall is due to two different causes—the currents of daytime convection and the nightime cooling. The first produce the showers and vary as the intensity of the rainfall. The second, which gives longer period of rainfall, seems to be related to what we have called *the degree of persistence* of rainfall. According to the direction of the wind, one or the other of these two causes predominates.

European weather in August—London heat wave.—London experienced the warmest night ever recorded in the last week of August, with a temperature of 84° in the shade in the morning and a maximum of 88° in the afternoon. The heat wave extended over the British Isles, parts of Europe, and the African coast.

The heat overcame the British tradition of never discarding vest or even coat. When the temperature reached 92° at 3 p. m. August 27 stockbrokers in shirt sleeves but still wearing their top hats astonished the business section of the city.

France also suffered from the heat; a maximum temperature of 95° in Paris and 102° in the Seine Valley were recorded.

Cloudy, chilly, and wet.—While crops have burned in the United States, they have molded and rotted in parts of Europe. In Germany August has been the wettest month of that name in 20 years; a protracted rainy period which followed the prolonged June drought retarded the progress of all German crops.

Reports from various countries where harvesting operations are about to begin show that Russia and Rumania probably will be the only ones with surplus cereal crops for export, while England, France, Italy, Germany, and Austria will have subnormal yields of wheat, rye, oats, and barley.

Torrential rains in northern China.—While the United States is still in the grip of an unprecedented drought, news dispatches tell of torrential rains in northern China and an estimated loss of 1,000 lives by drowning in the flooded area. The rains also interfered with fighting between Nationalist troops and their foes in the Province of Shantung. The greatest loss of live and damage to property occurred in the low country between Peiping and Mukden, in Manchuria, during the first 10 days of August.

[1] Note by M. Louis Besson, presented by M. Bigourdan. *Comptes Rendus*, des séances de l'Academie des Sciences, tome 191, No. 3, July 21, 1930, p. 146–148. Translated by Katharine B. Clarke.

Torrential rains occurring in the barren country about 120 miles from Kalgoorlie, Australia, are reported as having washed away a few inches of surface soil, disclosing gold-bearing quartz reefs which are expected to prove the richest Australian find in many years.

A dispatch from Capetown, South Africa, under date of August 12, reports the end of South Africa's drought, due to a severe storm that swept over many parts of the union, attended by gales of wind and heavy rain. Rain fell even upon Little Namaqualand district of Cape Colony, parts of which had experienced a phenomenal drought that lasted five years.—*A. J. H.*

International ice observation and ice-patrol service in the North Atlantic Ocean, season of 1929.[2]—The ice patrol report is more than a record of icebergs, currents, and navigation; it is full of the climate of a chilly, foggy region. In fact, it is the fogginess of the climate that makes the patrol necessary. And on account of this fog the patrol can not remove the menace of icebergs in steamer lanes, for with fog prevailing a third of the time, sometimes for days together, icebergs, traveling often 24 or more miles a day, can slip unseen into the path of steamers.

The interesting running account of the patrol is supplemented by special discussions, the first of which is "Weather." (Pp. 67–74, figs. 2–5.) The mean air temperature rose from 40° in April and 43° in May to 51° in June and 60° in July. The sea-surface temperature rose nearly as much, but averaged a few degrees lower. The lowest and highest air temperatures were 30° and 73°. Weather diagrams, on polar coordinates, show the details of daily pressure winds and visibility. The reduced frequency of gales from spring to summer is a striking feature of the climate. Local differences in fogginess and air temperature correspond closely to those of sea-surface temperature and to the direction of the wind.

The warm air of southerly winds usually becomes chilled and foggy over the cold water, while the cold air of northerly winds frequently makes a "steam" fog over the warm water of the Gulf Stream. The sea temperature differs by 25 or more degrees F. in a short distance. To use its time most effectively the patrol ship is usually directed into the fog-free warm water during periods of southerly winds and into the cold water when northerly winds blow. In its operation the weather reports received frequently from many ships assist.—*C. F. B.*

Scirocco invasions of central Europe, by Martin Herrmann.[3]—Tropical continental air from the Sahara invades central Europe not infrequently, it seems. Air trajectories, and identification by potential temperature and other characteristics, as well as occasional falls of Sahara dust, are ample proof of the movements of large quantities of Sahara air over Europe. Though this air is dry for its high temperature, the absolute humidity is high enough for heavy, warm front rains, and even for thunderstorms, owing to the super-wet-adiabatic lapse rate (0.8° C. per 100 m.) in the air from the Sahara. Rains that flood the Po Valley are ascribable to Sahara air ascending on a 1 per cent gliding slope, while more moderate scirocco rains in central Europe have an intensity that would attend ascent on a slope half as steep.—*C. F. B.*

Meteorological summary for Chile, May, 1930 (by J. Bustos Navarrete, Observatorio del Salto, Santiago, Chile).—This month was characterized by weak atmospheric circulation over the Pacific Ocean and generally dry weather over Chile.

The most important depressions, those accompanied by unsettled weather and rain, were charted as follows: 1st–4th, crossing the extreme south; 12th–13th, over the central zone; and 23d–24th, over the southern region.

Anticyclones were mapped on the 4th–6th, 21st–23d, and 27th–31st; all moved from latitude 45 S. toward the central region of Argentina.—*Translated by W. W. R.*

Meteorological summary for Chile, June, 1930 (by J. Bustos Navarrete, Observatorio del Salto, Santiago, Chile).—With June there came a noticeable intensification in the circulation of the atmosphere over the Pacific Ocean, which caused increase in rainfall in the central and southern regions of Chile.

The depressions of the 3d–7th and 10th–13th brought heavy storms over the region from Aconcagua to Magallanes. Those of the 16th–20th and 24th–25th were of lesser intensity and crossed the extreme southern area.

Important anticyclonic centers were charted on the 2d–3d and 29th–30th; the first moved from south of Chile toward Argentina, the second formed near northern Chile, advanced southward, and then recurved toward Argentina. The formation and movement of the latter area caused an intense cold wave, with temperatures of −10° C. (14° F.) in the cordillera of Los Andes.—*Translated by W. W. R.*

Meteorological summary for Chile, July, 1930 (by J. Bustos Navarrete, Observatorio del Salto, Santiago, Chile.)—A greater activity in atmospheric circulation was evidenced by the more frequent occurrence of depressions and anticyclones. There was a general increase in rain in central and southern Chile.

The most important anticyclones were charted as follows: 1st–9th, moving from southern Chile toward Argentina, Uruguay, and Brazil, accompanied by a severe cold wave; 14th–17th, advancing from Magallanes toward northern Argentina and Brazil; 21st–22d, crossing central Chile toward Argentina; and lastly, 24th–30th, paralleling the cordillera from southern Chile to the Bolivian highland. The passage of each of these HIGHS was attended by fair weather, cold wave, and freezing.

The days on which conditions were determined by the presence of depressions were the following: 7th–11th, 14th–15th, 16th–19th, 22d–23d, and 26th–30th. The first storm crossed the extreme southern region and brought general rain in southern and central Chile; the second appeared off Coquimbo; the third advanced from the extreme south to central Chile, attended by high winds, rain, and snow; the fourth and fifth crossed the extreme south and were accompanied by rain and snow, high winds, and displays of electricity.—*Translated by W. W. R.*

[2] U. S. Treasury Department, U. S. Coast Guard, Bull. No. 18, Washington, 1930. 141 pp., 17 pl., 33 figs. tables.

[3] Herrmann, Martin, Scirocco-Einbrüche in Mitteleuropa (Ein Beitrag zur Analyse der 5-b-Depressionen vom 25. April und 16. Mai, 1926). Veröff. d. Geoph. Inst d. Univ. Leipzig. 2d ser. of spec. works, vol. 4, p. 181–252, 6 pl., tables, bibliog.

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SOLAR OBSERVATIONS

SOLAR AND SKY RADIATION MEASUREMENTS DURING AUGUST, 1930

By HERBERT H. KIMBALL

For reference to descriptions of instruments and exposures, and an account of the method of obtaining and reducing the measurements, the reader is referred to this volume of the REVIEW, page 26.

Table 1 shows that solar radiation intensities were close to the normal intensity for August at Washington, D. C., and decidedly below at Madison, Wis., and Lincoln, Neb.

Table 2 shows an excess in the total solar radiation received on a horizontal surface directly from the sun and diffusely from the sky at Washington, Madison, and New York, a marked deficiency at Chicago and Lincoln, and a slight deficiency at Fresno and La Jolla, as compared with the normal amounts received at the respective stations in August.

Skylight polarization measurements obtained at Washington on four days during the month give a mean of 57 per cent and a maximum of 62 per cent on the 12th. At Madison measurements obtained on eight days give a mean of 48 per cent and a maximum of 59 per cent on the 12th. The values for Washington are slightly above, and those for Madison are decidedly below, the corresponding August averages for the respective stations.

TABLE 1.—*Solar radiation intensities during August, 1930*

[Gram-calories per minute per dquare centimeter of normal surface]

Washington, D. C.

Date	Sun's zenith distance: 8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass: A. M.					P. M.				Local mean solar time
	c.	5.0	4.0	3.0	2.0	1 1.0	2.0	3.0	4.0	5.0	c.
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Aug. 4	13.61			0.71	0.88	1.02					16.79
Aug. 7	17.37				0.82						11.81
Aug. 8	19.23				0.64	0.83					12.68
Aug. 11	6.27	0.76	0.85	0.97							7.29
Aug. 12	6.76			1.08	1.12	1.28					5.56
Aug. 19	10.21				0.90						9.14
Aug. 25	9.83	0.48	0.58	0.71	1.01	1.15					9.14
Means		(0.62)	(0.72)	0.87	0.90	1.07					
Departures		±0.00	+0.05	+0.12	−0.02	−0.15					

TABLE 1.—*Solar radiation intensities during August, 1930*

Madison, Wis.

Date	Sun's zenith distance: 8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.6°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass: A. M. 5.0	4.0	3.0	2.0	1.0	P. M. 2.0	3.0	4.0	5.0	Local mean solar time
	e.										e.
	mm.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm.
Aug. 1	9.83				1.08						11.38
Aug. 12	8.81			0.95	1.16						8.18
Aug. 14	11.81				0.84	1.15					13.13
Aug. 15	13.13		0.66	0.78	1.01	1.22					11.38
Aug. 18	10.59		0.76	0.90	1.08	1.36					8.48
Aug. 21	11.38		0.72	0.85	1.06	1.36					10.21
Aug. 22	10.59		0.82	0.97	1.12	1.27					8.18
Aug. 23	9.83			0.70	0.92	1.17					9.47
Aug. 25	10.21				0.79	0.97					11.38
Aug. 29	11.38				1.18	1.40					7.29
Means			0.74	0.86	1.02	1.24					
Departures			−0.09	−0.07	−0.07	−0.07					

Lincoln, Nebr.

Aug. 4	11.81				1.01						21.97
Aug. 20	12.68			0.93							15.11
Aug. 25	13.13			0.59	0.77						14.10
Aug. 26	13.61			0.72	0.91	1.22	0.87	0.67	0.51	0.37	11.81
Aug. 31	13.13		0.56	0.75	0.99	1.28					14.60
Means			(0.56)	0.75	0.92	(1.25)	(0.87)	(0.67)	(0.51)	(0.37)	
Departures			−0.21	−0.15	−0.16	−0.05	−0.20	−0.22	−0.24	−0.32	

[1] Extrapolated.

TABLE 2.—*Total solar radiation (direct+diffuse) received on a horizontal surface*

[Gram-calories per square centimeter]

Week beginning	Average daily totals: Washington	Madison	Lincoln	Chicago	New York	Pittsburgh	Gainesville	Fresno	La Jolla	Miami
1930										
July 30	530	476	518	327	470	493	498	642	380	510
Aug. 6	483	531	379	360	399	429	482	636	286	542
Aug. 13	367	456	412	323	278	331	466	672	376	404
Aug. 20	407	450	408	372	262	295	514	556	468	471
Aug. 27	449	403	434	232	286	233	411	612	454	496
	Departures from weekly normals									
July 30	+76	+13	−4	−37	+92			−26	−26	
Aug. 6	+46	+71	−113	+6	+47			−10	−106	
Aug. 13	−61	+15	−72	−37	−49			+51	−39	
Aug. 20	−6	+14	−82	+10	−46			−47	+21	
Aug. 27	+32	−5	−20	−116	−21			+16	+50	
Accumulated departures on Sept. 2, 1930	+4,676	+343	−1,904	+665	−21			−1,709	−2,92[illegible]	

POSITIONS AND AREAS OF SUN SPOTS

[Communicated by Capt. J. F. Hellweg, Superintendent United States Naval Observatory. Data furnished by Naval Observatory, in cooperation with Harvard, Yerkes, Perkins, and Mount Wilson Observatories. The differences of longitude are measured from central meridian, positive west. The north latitudes are plus. Areas are corrected for foreshortening and are expressed in millionths of sun's visible hemisphere. The total area, including spots and groups, is given for each day in the last column]

Date	Eastern standard civil time	Heliographic: Diff. long.	Longitude	Latitude	Area: Spot	Group	Total area for each day
1930	h m	°	°	°			
Aug. 1 (Naval Observatory)	10 32	−53.5	160.5	−8.5	6		
		+25.0	239.0	+1.5	12		18
Aug. 2 (Naval Observatory)	10 47	−39.5	161.1	−8.5	6		
		+39.0	239.6	+1.5	6		12
Aug. 3 (Naval Observatory)	11 42	−25.0	161.9	−9.0	6		6
Aug. 4 (Naval Observatory)	10 53	−12.5	161.6	−9.0	3		3
Aug. 5 (Naval Observatory)	10 50			No spots			
Aug. 6 (Mount Wilson)	11 40	−78.0	69.1	−8.0	333		
		−54.0	93.1	+4.0		40	373
Aug. 7 (Naval Observatory)	10 47	−61.5	73.0	−6.5	262		
		+8.0	142.5	−2.0	3		265

Positions and areas of sun spots—Continued

Date	Eastern standard civil time	Heliographic: Diff. long.	Longitude	Latitude	Area: Spot	Group	Total area for each day
1930	h m	°	°	°			
Aug. 8 (Naval Observatory)	10 49	−48.0	73.2	−6.0	201		
		−25.0	96.2	+4.5	2		203
Aug. 9 (Naval Observatory)	10 46	−35.0	73.0	−6.5		231	
		−12.5	95.5	+4.5		9	240
Aug. 10 (Naval Observatory)	11 57	−20.5	73.7	−6.5	231		
		+2.5	96.7	+4.5		18	249
Aug. 11 (Naval Observatory)	11 6	−8.0	73.4	−7.0	231		
		+16.0	97.4	+3.5	6		237
Aug. 12 (Naval Observatory)	10 46	+5.5	73.9	−7.0	231		
		+29.5	97.9	+4.0	3		234
Aug. 13 (Naval Observatory)	10 46	+18.0	73.2	−7.0		278	278
Aug. 14 (Naval Observatory)	12 45	+32.5	73.3	−6.5	231		231
Aug. 15 (Naval Observatory)	10 44	+45.0	73.7	−6.5	216		216
Aug. 16 (Naval Observatory)	10 42	+58.5	74.0	−6.5	216		216
Aug. 17 (Naval Observatory)	11 19	+72.5	74.5	−7.0	216		216
Aug. 18 (Naval Observatory)	10 48	−81.0	268.0	+7.0	123		
		−77.0	272.0	−12.5	77		200
Aug. 19 (Naval Observatory)	10 46	−67.0	268.8	+6.5	108		
		−63.0	272.8	−12.0	77		
		−55.5	280.3	+10.0	9		194
Aug. 20 (Naval Observatory)	10 49	−54.5	268.1	+6.5		123	
		−49.5	273.1	−12.0	62		
		−41.5	281.1	+10.0		12	197
Aug. 21 (Naval Observatory)	10 49	−42.5	266.9	+6.5		139	
		−35.5	273.9	−12.0	40		
		−26.5	282.9	+10.0		3	182
Aug. 22 (Perkins Observatory)	15 11	−32.0	261.5	−15.0		201	
		−21.5	272.0	−6.0		155	
		−20.0	273.5	−12.5		186	542
Aug. 23 (Naval Observatory)	11 31	−16.5	266.1	+6.5		93	
		−12.0	270.6	−12.5		62	
		+6.0	288.6	+6.5	3		158
Aug. 24 (Naval Observatory)	12 10	−71.5	197.5	−11.0		62	
		−14.0	255.0	−15.0	3		
		−3.0	266.0	+6.0		62	
		+2.5	271.5	−12.5		62	
		+21.5	290.5	+7.0	6		195
Aug. 25 (Naval Observatory)	10 47	−67.5	199.1	−10.0		123	
		+10.0	266.6	+7.0		62	
		+16.5	273.1	−12.5		22	
		+32.5	289.1	+7.0		15	222
Aug. 26 (Naval Observatory)	10 44	−55.0	188.4	+6.5	18		
		−43.5	199.9	−10.5		31	
		+25.0	268.4	+5.0	37		
		+45.0	288.4	+7.0		31	117
Aug. 27 (Naval Observatory)	10 56	−83.5	146.6	+10.5	185		
		−42.0	188.1	+7.5		46	
		−30.0	200.1	−10.0		34	
		+39.0	269.1	+5.0	31		296
Aug. 28 (Naval Observatory)	10 46	−70.0	146.9	+10.0	68		
		−30.0	186.9	+7.5		170	
		−16.5	200.4	−10.5		31	
		+52.0	268.9	+5.0	18		287
Aug. 29 (Naval Observatory)	10 44	−57.0	146.7	−13.5		46	
		−56.0	147.7	+10.0	56		
		−17.5	186.2	+8.0		170	
		−3.0	200.7	−10.0		31	303
Aug. 30 (Naval Observatory)	11 7	−42.5	147.8	+9.5	56		
		−42.0	148.3	−13.5		34	
		−4.0	186.3	+7.5		77	
		+10.0	200.3	−10.5		25	192
Aug. 31 (Naval Observatory)	11 48	−28.5	148.2	+9.5	40		
		−28.0	148.7	−13.5		28	
		+10.5	187.2	+7.5		68	
		+24.0	200.7	−10.5		40	176
Mean daily area for August							202

PROVISIONAL SUN-SPOT RELATIVE NUMBERS FOR AUGUST, 1930 [1]

[Data furnished through the courtesy of Prof. W. Brunner, University of Zurich, Switzerland]

August, 1930	Relative numbers	August, 1930	Relative numbers	August, 1930	Relative numbers
1	17	11	22	21	31
2	23	12	a 21	22	28
3	7	13	23	23	38
4	7	14	13	24	a 37
5	7	15	11	25	41
6	d 17	16	10	26	Ec 35
7	19	17	10	27	37
8	13	18	d 21	28	43
9	21	19	23	29	53
10	20	20	29	30	a 50
				31	a 47

Mean, 31 days=25.0.

[1] Dependent alone on observations at Zurich and its station at Arosa.
a=Passage of an average-sized group through the central meridian.
c=New formation of a large or average-sized center of activity: E, on the eastern part of the sun's disk; W, on the western part; M, in the central zone.
d=Entrance of a large or average-sized center of activity on the east limb.

AEROLOGICAL OBSERVATIONS

By RICHMOND T. ZOCH

Free-air temperatures were mostly above normal at Broken Arrow and Ellendale and in the lower levels at Royal Center. At Due west and Groesbeck and in the upper levels at Royal Center they were mostly below normal. In all cases the departures were small.

Free-air relative humidities were mostly below normal at Broken Arrow, Due West, and Royal Center. At Ellendale and Groesbeck they were mostly above normal.

Free-air vapor pressures were above normal at Ellendale and in the upper levels at Broken Arrow and Royal Center. At Due West and Groesbeck and in the lower levels at Broken Arrow and Royal Center the free-air vapor pressures were below normal.

Free-air resultant winds were variable in the lower levels. At the 3,000-meter level, and above, they were predominately westerly.

TABLE 1.—*Free-air temperatures, relative humidities, and vapor pressures during August, 1930*

TEMPERATURE (° C.)

Altitude (meters) m. s. l.	Broken Arrow, Okla. (233 meters)		Due West, S. C. (217 meters)		Ellendale, N. Dak. (444 meters)		Groesbeck, Tex. (141 meters)		Royal Center, Ind. (225 meters)	
	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal
Surface	25.8	−0.9	23.9	−1.6	21.2	+1.0	24.3	−2.5	23.4	−0.1
500	25.8	+0.5	22.3	−0.7	20.9	+0.9	23.6	−0.7	22.2	+1.0
1,000	23.8	+0.9	20.0	0.0	19.4	+1.3	23.2	+1.0	19.2	+1.2
1,500	20.5	+0.7	16.5	−0.4	16.9	+1.4	19.8	+0.3	15.5	+0.4
2,000	17.0	+0.6	12.6	−1.1	13.7	+1.1	16.3	−0.3	12.0	−0.3
2,500	13.8	+0.8	8.9	−1.7	10.2	+0.6	------	------	8.3	−1.4
3,000	10.9	+1.1	5.3	−2.4	6.9	+0.3	------	------	4.9	−2.0
4,000	5.4	+1.7	0.2	−1.8	0.4	−0.4	------	------	0.3	−1.3
5,000	------	------	------	------	−4.8	+0.1	------	------	−4.7	−1.1

TABLE 1.—*Free-air temperatures, relative humidities, and vapor pressures during August, 1930*—Continued

RELATIVE HUMIDITY (%)

Altitude (meters) m. s. l.	Broken Arrow, Okla. (233 meters)		Due West, S. C. (217 meters)		Ellendale, N. Dak. (444 meters)		Groesbeck, Tex. (141 meters)		Royal Center, Ind. (225 meters)	
	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal
Surface	64	−3	70	+1	63	−3	81	+8	62	−5
500	57	−7	65	−5	63	−1	76	+2	54	−12
1,000	52	−9	61	−9	58	0	51	−11	54	−13
1,500	54	−7	62	−8	57	0	58	−2	58	−7
2,000	57	−6	65	−4	57	+2	66	+7	60	−1
2,500	60	−3	67	−1	56	+2	------	------	62	+7
3,000	61	−2	70	+3	55	+1	------	------	68	+17
4,000	59	+4	72	+1	56	+6	------	------	42	−4
5,000	------	------	------	------	53	+7	------	------	25	−19

VAPOR PRESSURE (*mb.*)

Surface	21.02	−1.97	20.82	−1.60	15.26	+0.12	24.58	−0.75	17.51	−1.74
500	18.89	−1.54	17.68	−1.94	15.01	+0.25	21.90	−0.30	14.47	−2.33
1,000	15.52	−1.18	14.36	−2.00	12.56	+0.70	14.39	−2.14	12.15	−1.90
1,500	13.46	−0.43	11.83	−1.69	10.58	+0.76	13.36	−0.18	10.38	−1.05
2,000	11.36	−0.24	9.68	−1.26	8.62	+0.73	12.19	+1.00	8.76	−0.13
2,500	9.72	+0.37	7.76	−1.05	6.69	+0.27	------	------	7.32	+0.67
3,000	8.16	+0.69	6.18	−1.02	5.44	+0.12	------	------	6.43	+1.33
4,000	5.37	+1.30	3.44	−1.74	3.82	+0.34	------	------	3.74	+0.50
5,000	------	------	------	------	2.66	+0.51	------	------	2.84	+0.85

TABLE 2.—*Free-air data obtained at naval air stations during August, 1930*

Altitude (meters) m. s. l.	TEMPERATURE (°C.)					RELATIVE HUMIDITY (%)				
	Hampton Roads, Va.	Pensacola, Fla.	San Diego, Calif.	Seattle, Wash.	Washington, D. C.	Hampton Roads, Va.	Pensacola, Fla.	San Diego, Calif.	Seattle, Wash.	Washington, D. C.
Surface	24.4	24.7	23.1	21.2	21.5	69	86	73	60	68
500	21.7	24.0	21.0	16.8	21.0	62	74	69	68	58
1,000	19.7	21.2	23.8	14.8	19.1	57	70	38	63	53
2,000	12.5	14.4	20.5	10.4	13.1	60	71	32	51	56
3,000	6.8	8.7	13.2	4.2	6.7	41	62	37	33	56
4,000	------	------	------	−4.1	0.4	------	------	------	33	56

TABLE 3.—*Free-air resultant winds (meters per second) based on pilot-balloon observations made near 7 a. m. (E. S. T.) during August, 1930*—Continued

Altitude (meters) m. s. l.	Broken Arrow, Okla. (233 meters)		Burlington, Vt. (132 meters)		Cheyenne, Wyo. (1,873 meters)		Due West, S. C. (217 meters)		Ellendale, N. Dak. (444 meters)		Groebeck, Tex. (139 meters)		Havre, Mont. (762 meters)		Jacksonville, Fla. (65 meters)		Key West, Fla. (11 meters)		Los Angeles, Calif. (145 meters)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°	
Surface	S 18 W	1.8	S 5 W	1.6	N 83 W	2.6	N 4 E	0.3	S 38 E	0.4	S 14 W	1.8	S 54 E	0.1	N 36 W	1.0	S 59 E	1.0	N 69 W	1.6
500	S 14 W	7.5	S 48 W	3.3	------	------	N 22 W	1.0	S 46 E	1.2	S 38 W	8.4	------	------	N 22 W	1.9	S 55 E	2.5	E	1.1
1,000	S 36 W	6.8	N 78 W	3.5	------	------	N 28 W	1.6	S 3 E	3.2	S 30 W	6.7	S 46 E	0.9	N 7 W	1.4	S 41 E	2.5	S 56 E	1.2
1,500	S 48 W	4.7	N 80 W	5.0	------	------	N 35 W	1.9	S 57 W	1.9	S	3.4	S 44 W	1.9	N 19 W	2.0	S 29 E	1.2	S 19 W	1.8
2,000	S 58 W	3.3	N 65 W	6.0	N 85 W	3.9	N 26 W	2.4	N 87 W	2.5	S 32 E	1.4	S 85 W	2.3	N 35 W	1.7	S 37 E	0.7	S 43 W	3.7
2,500	S 58 W	2.5	N 67 W	7.1	W	3.9	N 42 W	2.5	N 69 W	3.3	N 81 E	1.3	N 89 W	3.1	N 43 W	2.0	S 35 W	0.9	S 29 W	5.1
3,000	N 88 W	2.4	N 63 W	9.4	S 87 W	3.4	N 46 W	2.7	N 56 W	4.4	N 57 E	1.7	S 80 W	3.9	N 76 W	2.5	S 87 W	1.3	S 18 W	6.8
4,000	S 81 W	0.3	N 56 W	7.9	N 84 W	5.6	N 37 W	3.5	N 63 W	7.2	S 65 E	3.1	S 78 W	7.4	N 78 W	4.5	S 75 W	1.1	S	4.4
5,000	N 23 W	1.5	------	------	S 84 W	7.6	N 58 W	4.1	N 58 W	8.5	N 43 E	4.1	S 76 W	7.3	N 88 W	5.1	W	1.6	------	------

Altitude (meters) m. s. l.	Medford, Oreg. (410 meters)		Memphis, Tenn. (145 meters)		New Orleans, La. (25 meters)		Omaha, Nebr. (321 meters)		Royal Center, Ind. (225 meters)		Salt Lake City Utah (1,294 meters)		San Francisco, Calif. (2 meters)		Sault Ste. Marie, Mich. (198 meters)		Seattle, Wash. Wash. (14 meters)		Washington, D. C. (10 meters)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°	
Surface	S 56 W	0.5	S 41 E	0.5	N 7 E	0.4	S 60 E	1.5	S 53 E	0.6	S 52 E	2.5	N 78 W	4.0	N 17 W	0.6	S 31 E	0.3	S 36 E	0.
500	N 89 W	0.8	S 52 W	2.3	N 61 W	1.4	S 21 E	4.4	S 6 E	1.1	------	------	N 62 W	5.3	N 31 W	1.9	S 80 E	0.4	N 14 W	2.6
1,000	N 60 W	1.2	N 82 W	2.1	S 63 W	1.0	S 5 W	5.4	N 65 W	2.1	------	------	N 40 W	3.8	N 49 W	4.8	N 65 E	0.3	N 30 W	2.3
1,500	S 72 E	0.5	N 57 W	2.7	S 6 E	0.6	S 46 W	4.3	N 52 W	3.7	S 22 E	5.0	N 89 W	2.4	N 47 W	4.6	N 70 W	0.6	N 35 W	4.0
2,000	S 56 E	1.7	N 47 W	3.5	S 28 E	0.8	S 70 W	4.6	N 49 W	5.1	S	4.9	S 45 W	3.7	N 40 W	5.9	S 77 W	1.1	N 38 W	6.1
2,500	S 5 W	3.4	N 39 W	3.3	N 89 E	1.3	N 85 W	5.9	N 44 W	6.0	S 31 W	3.4	S 28 W	4.6	N 44 W	7.1	S 47 W	1.3	N 58 W	6.5
3,000	S 11 W	5.5	N 18 W	3.3	N 37 E	1.4	N 82 W	6.4	N 44 W	6.9	S 54 W	4.0	S 32 W	5.8	N 40 W	8.0	S 19 W	2.4	N 58 W	6.3
4,000	S 39 W	8.7	N 47 W	5.0	N 49 E	3.1	N 71 W	6.1	N 46 W	9.3	S 53 W	4.4	S 30 W	8.1	------	------	------	------	N 66 W	6.3
5,000	------	------	------	------	N 20 E	3.2	N 53 W	5.7	N 50 W	12.0	------	------	S 38 W	11.1	------	------	------	------	------	------

TABLE 4.—*Observations by means of kites, captive and limited-height sounding balloons during August, 1930*

	Broken Arrow, Okla.	Due West, S. C.	Ellendale, N. Dak.	Groesbeck, Tex.	Royal Center, Ind.
Mean altitudes (meters), m. s. l., reached during month	2,755	2,576	2,866	1,873	3,058
Maximum altitude (meters), m. s. l., reached and date	[1] 4,381	[2] 4,641	[3] 6,528	[4] 2,386	[5] 8,201
Number of flights made	29	31	31	20	27
Number of days on which flights were made	29	31	31	20	27

[1] 20th. [2] 18th. [3] 24th. [4] 31st. [5] 26th; captive balloon breakaway; next highest flight at Royal Center was a kite flight to 6,130 meters on the 21st.

In addition to the above there were approximately 130 pilot balloon observations made daily at 55 Weather Bureau stations in the United States.

WEATHER IN THE UNITED STATES

THE WEATHER ELEMENTS

By M. C. BENNETT

GENERAL SUMMARY

The weather for August was extremely hot almost everywhere during the first decade, but as it ended cool weather overspread the central and northern districts, and light frosts were reported on the 13th in southern New York, western Pennsylvania, and West Virginia. During the remainder of the month the weather was cool in most sections from the Rocky Mountains eastward, except temperatures above normal prevailed in the western Great Plains and northwestern Rocky Mountain areas. The month as a whole was warmer than normal except in northern New England, New Jersey, West Virginia, the South Atlantic States, and the far Southwest.

While moderate to substantial showers were received over limited areas during the month, which relieved the severe droughty conditions in some sections, the month generally had very scanty rainfall, and the severe drought remained largely unbroken. The deficiencies in precipitation for the month were widespread, with every State east of the Rocky Mountains, except South Dakota and Nebraska, receiving less than normal. The areas of greatest deficiency for the month were in the Northern and Southeastern States, where droughty conditions had not been so generally severe during July. The least rainfall of August record was received this month in Minnesota, Pennsylvania, Maryland, and Virginia.

TEMPERATURE

While marked changes occurred in most sections, yet August, as a whole, was considerably hotter than normal. The first decade temperature, especially, was a continuation of the situation of the latter half of July, all districts save a few southwestern, southeastern, and northeastern having temperatures moderately to decidedly above normal.

The middle of the month was notable for cool weather for summer in a great many regions, yet the Plains States and the Northwest remained decidedly hot. The first half of the final decade was cool in the eastern half of the country, but hot over most of the western half, especially in the northern Rocky Mountain region. The last few days of the month were hotter than normal over nearly all the country, especially from the upper Mississippi Valley eastward to the Middle Atlantic States.

August averaged cooler than normal only near the Atlantic and east Gulf coasts and in the southern Appalachian region, and over considerable portions of California, Arizona, and Nevada. In other regions the month averaged warmer than normal, and generally from 2° to 5° warmer in the northern Rocky Mountain region, the Missouri and upper Mississippi Valleys, and the upper Lake region. In North Dakota the month was as hot as any preceding August of record.

In all States east of the Mississippi River, and in almost all Middle and Northern States to westward, the highest temperatures occurred during the first decade, very often on either the 2d, 3d, or 4th. In most States which touch either the Mississippi or the Ohio River, and in several Middle Atlantic States, the highest marks of previous August records were exceeded or equaled or very closely approached. In Tennessee 113°, on the 9th, was 5° above any mark of an earlier August, and in Minnesota 109°, on the 3d, was 4° above.

In the northern and middle portions of the eastern half of the country, the drop in temperature near the end of the first decade was very pronounced, and the lowest readings of the month were noted about the 10th to 14th. In West Virginia, 112° had been recorded on the 4th, 2° above any previous state record; but only eight days later other places in the State noted 30°, 1° below any other August record.

In most of the cotton States, and most States of the western half of the country, the lowest readings of the present August occurred chiefly on or after the 20th, and only in the South Atlantic States were they noteworthy in comparison with what earlier Augusts had brought.

PRECIPITATION

Scanty precipitation, particularly over the eastern half of the country, was once more a conspicuous feature. East of the ninety-fifth meridian not one of the States received a normal amount of rainfall, and nearly one-third of them received less than 40 per cent of the normal. The scarcity of August precipitation was very marked in the more elevated portions of Georgia and South Carolina, in the interior sections of the Middle Atlantic States, and from Michigan to Minnesota.

Among the districts which had suffered great scarcity of moisture during July, the Ohio and lower Mississippi Valleys received mainly about two-thirds of the normal August quantities, so conditions improved somewhat. However, the distribution within the States was poor, also the important rains seldom came till about the middle of the month, when the possibility of benefit to staple crops had become less than it was at the close of July.

This summer has been the driest within the period well covered by records from Arkansas and Mississippi northeastward to the southern Middle Atlantic States. In Arkansas the summer June to August, brought about one-third the normal precipitation. In Kentucky the sixth months, March to August inclusive, were all deficient in precipitation, the whole period showing not quite half

the normal quantity. Several other States have been almost as unfortunate as these two.

The western half of the country received more nearly its normal precipitation during August, in fact from Nevada and northern Arizona northeastward to the middle Missouri Valley there was more than normal, particularly in southern, central, and western Wyoming and southeastern Idaho. In Wyoming it was considerably the wettest August of record.

The western districts near the Canadian boundary mainly had less rain than normal, and the same was true of the southern half of the Plains of New Mexico, save the western part, and of nearly all of Texas, especially the southern part.

SUNSHINE AND RELATIVE HUMIDITY

Much sunshine prevailed during the month throughout the country except in northeastern New England, a small area in the central Great Plains, and the northern Pacific area, where less than 40 per cent of the possible was observed. However, in portions of the upper lake region, the western portions of Kansas, Oklahoma, and Texas, and from western Texas to the Pacific, except a small area in southwestern California, most localities received more than 70 per cent of sunshine, while southwestern Arizona and the eastern and central portions of California received from 81 to 94 per cent of the possible amount for the month.

The extreme droughty conditions that prevailed over the country as a whole are reflected by the humidity percentages, which, over much of the country are found to be below the normal, the deficiencies ranging up to as great as 25 per cent in some sections of the Southeast. On the other hand, the humidity percentages were above the normal in portions of northern New England, the central Great Plains and the Rocky Mountain and Plateau regions, where the severe droughty conditions did not prevail.

SEVERE LOCAL STORMS, AUGUST, 1930

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A more complete statement will appear in the Annual Report of the Chief of Bureau]

Place	Date	Time	Width of path, yards [1]	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
Ipswich to Aberdeen, S. Dak.	1	3:30 p. m.			$13,000	Wind and hail	Buildings damaged or wrecked; crops ruined	Official, U. S. Weather Bureau.
Antreville (near), Calhoun Falls and Abbeville, S. C.	1	10:30 p. m.	2 mi.		35,000	Hail	Crops and other property on 3,000 acres damaged.	Do.
Crown Point, N. Mex.	1					Severe electrical and hail.	Character of damage not reported	Do.
Woodruff, S. C.	1				4,000	Hail	Crops damaged	Do.
Durand, Wis.	2	11:30 a. m.	6 mi.		4,000	Hail and rain	Many windows broken; roofs damaged; crops injured; main streets flooded.	Do.
Huron, S. Dak.	2	4:50 p. m.	50		3,000	Wind	Buildings damaged	Do.
Beadle County, S. Dak.	3	6–7 p. m.			12,000	Wind and hail	Buildings and crops damaged over small area	Do.
Castleford to Buhl, Idaho.	3				25,000	Electrical and hail.	House and auto burned; severe crop damage	Do.
Morrison, Colo.	4	12:30 p. m.	2 mi.		7,000	Hail	Crops, roofs, and auto tops considerably damaged.	Do.
Parker, Colo.	4	5 p. m.	1–2 mi.			do	Character of damage not reported	Do.
Loganville Wis. (near)	4				8,000	Electrical	Barn and other small buildings wrecked	The Wisconsin State Journal (Madison, Wis.).
Westlake to Kooskia, Idaho.	4					Hail and wind	300,000 bushels of grain ruined	Official, U. S. Weather Bureau.
Marble Falls, Tex.	5	4:30 p. m.	1,320		25,000	Tornado	Roof of factory destroyed	Do.
Scandia (near) to Rydal (near), Kans.	5	6 p. m.	2,500		10,000	Hail	About 1,000 acres of corn badly damaged; path 5 miles long.	Do.
Tatum and Minden, Tex.	5	6:30 p. m.	880		3,000	Wind	Some damage to buildings and crops	Do.
Dubuque, Iowa	5				7,000	Wind, rain and electrical.	Several residences and barns fired by lightning	Do.
Aberdeen, S. Dak.	6	4:45 p. m.			3,000	Wind	Overhead wires damaged	Do.
Monroe County, Iowa	6	5:30 and 7 p. m.			3,200	Two wind and hail storms.	No details reported	Do.
Wayne and Jasper Counties, Iowa.	6	5:30 and 6:30 p.m.			6,500	Two wind storms	do	Do.
Polk County, Iowa	6	6 p. m.			8,200	Wind and hail	do	Do.
East Hartford Conn., and vicinity.	7	P. m.				Rain, hail and wind.	Chief damage to tobacco and fruit	Hartford Courant (Conn.)
Monetta, S. C.	8				1,000	Wind squall	Barn wrecked; a mule and two cows killed	Official, U. S. Weather Bureau.
Mount Carroll, Ill., and vicinity.	9	11–11:30 a. m.	880–1,760		2,500	Hail	Chief damage to crops, roofs, and glass; trees blown down; path 18 miles long.	Do.
Athens, Ill.	9	3 p. m.			3,000	Wind	Buildings damaged; corn flattened	Do.
Beardstown, Ill.	9	4 p. m.				Wind and hail	Crops, gardens, and roofs damaged	Do.
Joliet, Ill.	9	do			20,000	Wind and rain	Wire services impaired; several houses unroofed	Official, U. S. Weather Bureau.
Lyons, Nebr. (2 miles south).	9	6 p. m.	1,760		75,000	Hail	Severe crop loss; path 10 miles long	Do.
Louisville, Ky., and vicinity.	9	8 p. m.		1	50,000	Wind and severe thunderstorm.	Heavy property damage in the city; a number of planes damaged at Bowman Field; several persons injured.	Do.
Chester, S. C. (near)	9	9.30 p. m.			4,000	Electrical	Large barn struck; contents and 5 mules burned	Do.
Fort Wayne, Ind.	9				1,500	Wind	Trees blown down; telephone and traction service impaired.	Do.
Greensboro, N. C.	9		2 mi.			Thunderstorm and wind.	Trees broken; crops beaten; streets flooded; path 5 miles long	Do.
Clinton, Scott, Grundy, Jackson, Linn, Montgomery, Page, and Woodbury Counties, Iowa.	9	P. m.			28,000	Wind and hail	Crops and other property damaged	Do.
La Salle, De Pue, and Princeton, Ill., and vicinity.	9			2		Wind	Trees down; corn flattened; roofs and signs damaged; electric services interrupted; boat capsized.	Do.
Royal Center, Ind., and vicinity.	9					do	Fruit trees injured; buildings and crops damaged	Do.
Vincennes, Ind.	9				1,000	do	Wires and trees damaged	Do.
Cowpens, S. C.	10	P. m.			15,000	Electrical	Power house struck	Do.
Hicksville to Riverhead, Long Island, N. Y.	10				17,000	Rain, wind, and probably small tornado.	Much injury to crops, buildings, and trees; planes damaged; tornado near Hicksville.	Do.
Providence, R. I.	10	A. m.			8,400	Thunderstorm	Buildings damaged	Do.
Oktaha, Okla., (5 miles southeast).	11	4 p. m.	440		2,500	Hail	Chief damage to crops; path ¾ mile long	Do.

[1] "Mi." signifies miles instead of yards.

Severe local storms, August, 1930—Continued

Place	Date	Time	Width of path, yards [1]	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
Springfield, Ill.	13				$11,000	Severe electrical and wind.	Considerable damage by fires; minor injury to trees and wires by wind.	Official, U. S. Weather Bureau.
Dillon, Mont., and vicinity.	14					Hail	Crops damaged	Do.
Brooklyn, Wis.	15	3 p. m.	880		1,500	do	do	Do.
Byron, Nebr.	15	5:10 p. m.	1,760		17,500	do	Considerable damage to crops in places; path 10 miles long.	Do.
Hamburg, Pa.	15				20,000	Hail and several electrical storms.	Barn wrecked; all crops damaged	Do.
Connecticut and Massachusetts (parts of).	16			5	1,500,000	Wind, hail, electrical, and cloudburst.	Damage chiefly to tobacco; livestock killed; goods in cellars damaged.	Hartford, Courant (Conn.).
Clatonia, Nebr.	18	10:30 a. m.	1,320		2,000	Tornado and hail.	Barn wrecked; crops damaged; path 1.5 miles	Official, U. S. Weather Bureau.
Tullos, La. (near)	18	3 p. m.	440		3,000	Wind	Oil derricks damaged; path ½ mile long	Do.
Levy, N. Mex. (near)	18	3-3:30 p. m.	1,760			Hail	Character of damage not reported	Do.
Garland, Mont.	18					do	Much alfalfa seed destroyed	Do.
Wymore, Nebr.	19	10 a. m.	4 mi.		10,000	do	Crops damaged in places	Do.
Leesville, La.	19	3-3:30 p. m.	5 mi.		6,000	Hail and wind	Chief damage to crops; path 20 miles long	Do.
Arthur, Nebr. (5 miles east).	19	4 p. m.	440		25	Small tornado	Minor crop injury; path ½ mile long	Do.
Mineral Wells, Tex. (near).	19	do	1,760		1,200	Wind	Buildings damaged	Do.
Ville Platte, La. (5 miles east).	19	do	50		500	Probably tornado.	Cotton and small buildings damaged; path 1 mile long.	Do.
Larned to Belpre, Kans.	19	5-6 p. m.	2,500		75,000	Hail	Much damage to glass, roofs, and autos; crops badly cut.	Do.
Wauneta, Nebr.	19	do	1,760		8,000	do	Crop damage 35 per cent in places; path 7 miles long.	Do.
McCook, Nebr.	19	7:45 p. m.	2 mi.		20,000	do	Crops damaged; roofs pierced; path 20 miles long.	Do.
Greensburg to Wilmore, Kans.	19	11:30 p. m.	do			Hail and wind	Crops almost total loss in some localities; path 15 miles long.	Do.
Filley, Nebr.	19		3 mi.		3,000	Hail	Considerable crop injury over small areas; path 7 miles.	Do.
Superior, Nebr. to Glasco, Kans.	19		10 mi.			Violent wind and probably small tornado.	Trees, wires, and small buildings blown down; probably small tornado near Jamestown.	Do.
Geary, Okla.	20	2:30 a. m.	3 mi.		14,000	Wind	Chief damage to crops; path 9 miles long	Do.
Barnston, Nebr.	20	10 a. m.	2,640		9,000	Hail	Considerable crop damage in places; windows broken; some poultry killed; path 6 miles long.	Do.
Dane County, Wis. (eastern).	20	2-3 p. m.	880-1,760		100,000	do	Crops, especially tobacco, severely damaged; path 10 miles long.	Do.
Billings, Mont.	20	5-5:30 p. m.				do	10,000 acres of beets, beans, small grains, and alfalfa severely damaged.	Do.
Bon Homme County, S. Dak.	21	7 a. m.			25,000	Wind and hail	Buildings damaged and crops ruined in scattered areas.	Do.
Madison (northern), Pierce and Knox Counties, Nebr.	21	7-9 a. m.			10,000	Hail	Crops considerably damaged in small areas	Do.
Bruning, Nebr. (3 miles north).	21	1-2 p. m.	5 mi.		12,000	do	Damage to property light to heavy in places; path 35 miles long.	Do.
Monument, Colo.	21		2 mi.		10,000	do	Crops damaged; windows broken	Do.
Osmond, Nebr.	21		do		20,000	do	Crops damaged 5 to 10 per cent in places	Do.
Cotton and Jefferson Counties, Okla.	22	3 p. m.			375,000	Hail and wind	Heavy crop loss; much poultry and some livestock killed; 4 residences destroyed and 3 damaged.	Do.
Harmon County, Okla.	22	7 p. m.			15,000	Hail	Chief damage to crops	Do.
New York City, N. Y., and vicinity.	23	A. m.				Wind, rain, and electrical.	Cellars flooded; traffic halted; wires and trees broken; boats torn loose; some loss of life.	Do.
Gordon, Nebr.	23	3 p. m.	1,760		10,000	Hail and rain	Crops damaged in small areas; some damage by flooding.	Do.
Harriet and Wall, Tex.	24	7 p. m.	880		55,000	Tornado	Crops and buildings destroyed	Do.
Nolan, N. Mex. (near)	27	3-3:30 p. m.	2 mi.			Hail	Crops damaged about 40 per cent; path 2 miles long.	Do.
Alexandria, Nebr. (2 miles west).	28	4:30 p. m.	3 mi.		50,000	do	Serious crop damage in places; some roofs ruined; path 30 miles long.	Do.
Cedar Bluffs to Jennings, Kans.	28	6-6:30 p. m.	1-4 mi.		40,000	do	Chief damage to corn; path 20 miles long	Do.
Colmor, N. Mex. (near)	29	1:15-1:45 p. m.				do	Considerable damage to corn and beans	Do.
Fillmore, Thayer, Jefferson, and Gage Counties, Nebr.	30	1-5 p. m.	30 mi.		28,700	do	Crops damaged in scattered areas; path 70 miles	Do.
Table Rock, Nebr.	30	4-5 p. m.	2 mi.			do	Crops damaged	Do.

RIVERS AND FLOODS

By R. E. SPENCER

Except for unimportant rises in the Canadian River at Logan, N. Mex., and in the Colorado at Parker, Ariz., and for the high (artificial) stage of the Trinity River at Dallas, Tex., no flood stages were reached in the important rivers of the United States during August. No damage is reported in the above three cases.

In the Rocky Mountain region, and especially in Utah, considerable destruction was done by local floods resulting from so-called "cloudburst" rains. The Utah floods are discussed at length in an article by Mr. J. Cecil Alter, official in charge of the Weather Bureau office at Salt Lake City, appearing elsewhere in this REVIEW, and the following references to those in other Western States are based upon newspaper reports:

At Pocatello, Idaho, on August 9: Streets and private (residence) property in the western section of the city covered with mud and rock from adjacent mountain slope.

At Round Mountain, in southern Nevada, on August 12–13: Three houses and a hotel washed away.

On Rifle Creek, a small tributary of the Colorado River in Garfield County, Colo., on August 9: One life lost, a railroad bridge badly damaged, several highway bridges and a 60-foot section of highway washed out, considerable damage (chiefly to merchandise in basements) in the town of Rifle, and some livestock losses in the vicinity.

At Nogales, Ariz.-Sonora, Mex., on August 7: Two lives lost, 15 adobe buildings destroyed, 3,000 people rendered homeless, business houses flooded, electric power and telephone systems disabled. Damage estimated at several hundred thousand dollars, of which the greater part occurred in Sonora.

Owing to the continued dearth of rain in many sections, and the consequent continued fall in rivers, publication of a discussion of the effect of the drought on river stages is being deferred until some future issue of this REVIEW.

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
MISSISSIPPI DRAINAGE					
Canadian: Logan, N. Mex.	*Feet* 4	28	28	*Feet* 5.0	28
WEST GULF DRAINAGE					
Trinity: Dallas, Tex. (see note)	25	(1)	(2)	27.9	8
PACIFIC DRAINAGE					
Colorado: Parker, Ariz.	7	.....	28	10.5	June 7, 17–20

[1] Continued from last month.
[2] Continued at end of month.
NOTE.—Continued high stage at Dallas, Tex., an artificial condition caused by a temporary dam necessary in levee work below gage.

WEATHER OF THE ATLANTIC AND PACIFIC OCEANS

NORTH ATLANTIC OCEAN

By F. A. YOUNG

The outstanding feature of the month was the disturbance of tropical origin that was first reported on the daily weather map of August 25 as being central about 400 miles north-northeast of Porto Rico. However, reports received later by mail indicate that this storm was central near 21° N., 56° W., as early as the 22d. It apparently remained nearly stationary until the 25th, and was of comparatively slight intensity during this period.

Charts VIII to XIII cover the period from the 25th to 30th, and on Chart XIII the track of this storm is shown from the 22d to 31st.

The number of days with gales of extratropical origin did not differ greatly from the normal, as shown on the Pilot Chart, over the greater part of the ocean.

The number of days on which fog was reported in different localities is as follows: Over the Grand Banks, on from 11 to 14 days; along the American coast between the thirty-fifth and forty-fifth parallels, from 6 to 15 days; over the steamer lanes, between the twentieth and fortieth meridians, from 1 to 6 days; between the twentieth meridian and coast of Europe from 1 to 11 days.

Barometric data for several island and coast stations are given in the following table:

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, 8 a. m. (seventy-fifth meridian), North Atlantic Ocean, August, 1930*

Stations	Average pressure	Departure	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Julianehaab, Greenland	29.94	(1)	30.16	25th	29.58	20th.
Belle Isle, Newfoundland	29.95	[2]+0.06	30.28	24th	29.30	6th.
Halifax, Nova Scotia	30.01	[2] 0.00	30.28	30th	29.58	5th.
Nantucket	30.00	[3]−0.02	30.28	13th	29.74	10th.
Hatteras	30.01	[3]−0.03	30.24	13th	29.76	22d.
Key West	30.02	[3]−0.02	30.12	4th	29.84	21st.
New Orleans	30.03	[3]+0.01	30.14	4th [4]	29.92	20th. [4]
Cape Gracias, Nicaragua	29.92	[3]+0.03	29.98	5th [4]	29.86	15th. [4]
Turks Island	30.07	[3]+0.03	30.18	4th	29.96	26th.
Bermuda	30.08	[3]−0.06	30.30	4th [4]	29.60	26th.
Horta, Azores	30 19	[2]−0.01	30.15	15th	29.86	30th.
Lerwick, Shetland Islands	29.75	[2]−0.05	30.21	31st	29.18	14th.
Valencia, Ireland	29.88	[2]−0.04	30.32	31st	29.25	2d.
London	29.90	[2]−0.09	30.28	25th	29.47	3d.

[1] No normal available.
[2] From normals shown on Hydrographic Office Pilot Charts, based on observations at Greenwich mean noon, or 7 a. m., seventy-fifth meridian time.
[3] From normals based on 8 a. m. observations.
[4] And on other date or dates.

The first decade of the month was characterized by moderate weather over the ocean as a whole, except that on the 2d, 4th, and 5th moderate westerly gales prevailed along the coast of Europe, and on the 7th the station at Julianehaab, Greenland, reported wind southeast, force 9, barometer 29.76 inches, and there was apparently a well-developed depression over the region between Greenland and Newfoundland.

From the 11th to 19th moderate weather again prevailed over the greater part of the ocean, with the North Atlantic HIGH well developed, although on the 11th a LOW was over the Maritime Provinces, accompanied by moderate southerly gales between the fiftieth and sixtieth meridians, and on the 16th moderate gales were also reported between the fifteenth meridian and coast of Scotland.

On the 20th a LOW was central near 48° N., 18° W., with moderate gales between the twenty-fifth meridian and French coast; this moved rapidly eastward, and on the 21st was over northern Ireland, the storm area having diminished in extent and intensity. On the 20th there was also a depression off Hatteras that afterwards increased in intensity, remaining nearly stationary until the 22d, when the center was about 300 miles east of Nantucket.

As previously stated, the weather conditions from the 25th to 30th are shown on Charts VIII to XIII. The first observing vessel to note the tropical hurricane of this period, the approximate track of which is shown on Chart XIII, was the American steamship *Chincha*, Capt. H. J. Svenning; observer, William Sherwin. The *Chincha*, bound from Rio de Janeiro for Baltimore, came definitely within the influence of the hurricane on the 22d, when in latitude 21° 17′ N., longitude 56° 02′ W. At Greenwich noon of that date the barometer had fallen to 29.88 inches and the wind had backed from east-northeast to southwest and increased to force 7. The position of the vessel was therefore somewhere to the south and west of the storm center. Twenty-four hours later, when the *Chincha* had reached latitude 23° 24′ N., longitude 58° 22′ W., the wind had backed to east, indicating that the vessel had crossed the path at the rear of the center. Continuing on her course the *Chincha* reached latitude 27° 10′ N., 63° 16′ W. (D. R.), at Greenwich noon (7.47 a. m. L. M. T.), when it became apparent that the hurricane was recurving and approaching the vessel from the southward. The barometer now was 29.70 inches and the wind northeast, 10. At 3 p. m., local time, the ba-

rometer had fallen to 28.44 and the wind, still northeast, increased to full hurricane force. The decks were now awash under heavy breaking seas and some damage to superstructure being sustained. At 3.25 p. m. the vessel was hove to, head to sea. At 3.30 p. m. the wind shifted to southwest, force 12, barometer 28.36 inches; precipitous seas. From this time on wind and sea gradually diminished, and after being hove to for 18 hours and 35 minutes the *Chincha* was hauled back on her course.

On the morning of the 26th the hurricane passed near Bermuda, its course at that time being nearly due north, though continuing to recurve. By the morning of the 28th the center had reached latitude 41° 30′ N., longitude 55° W., and near here the French liner *Paris* was heavily involved. Captain Pugnet stated that the wind reached a velocity of 100 miles an hour and the barometer fell from 30.08 to 28.58 inches in a few hours. The storm report from the *Paris* is included in the table. According to press reports the ship was struck by one tremendous wave that smashed heavy glass along the port promenade and injured about 40 passengers, who were struck by flying glass.

From this time until the morning of the 30th the course of the hurricane was almost due east, and at Greenwich noon of that date it had reached longitude 22° 30′ W., still exhibiting hurricane strength. After this time, however, it lost energy and speed, and its course changed abruptly to the northward. It continued for some days as a disturbance of moderate intensity west of the British Isles.

The following report of a squall in the Florida Straits was received from Mr. W. P. Page, third officer, British steamship *Reventazon*, Capt. A. C. Woodhouse, from Tela, Honduras, toward Bremerhaven:

Monday, August 25, 9 p. m., Florida Straits, 23° 50′ N., 81° 35′ W.—Between 8 and 9 p. m. the sky gradually became overcast from all directions from west through north to east, with heavy black nimbus clouds giving every appearance of a heavy downpour of rain approaching. The wind was east-northeast, and at 9 p. m. it began to blow hard, and for an hour the wind was of force 9 to 10, in hot and cold blasts. The clouds broke up into dark patches of strato-cumulus clouds. The sea increased quickly to a rough sea. At 10 p. m. the clouds had blown over to the southwest in a dark black mass and the wind moderated as quickly as it had increased, backing to northeast, force 4. The squall was accompanied by vivid lightning. The sea moderated very quickly with the decrease in force of wind. The barometer was steady all the time at 29.80 inches (uncorrected). Air temperature, 83°; water, 83°.

OCEAN GALES AND STORMS, AUGUST, 1930

Vessel	Voyage		Position at time of lowest barometer		Gale began	Time of lowest barometer	Gale ended	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Highest force of wind and direction	Shifts of wind near time of lowest barometer
	From—	To—	Latitude	Longitude									
NORTH ATLANTIC OCEAN			° ′	° ′				*Inches*					
Polybius, Am. S. S.	Newcastle-on-Tyne.	New Orleans.	49 08 N	7 05 W	Aug. 1	11 p., 2	Aug. 3	29.33	SSE.	W, 10	WNW.	W, 10	
Reventazon, Br. S. S.	Avonmouth	Tela, Honduras.	49 00 N	10 50 W	Aug. 4	9 p., 4	Aug. 5	29.41	WSW.	SW, —	NW.	SW, 9	SW-W-WNW.
Sarcoxie, Am. S. S.	New York	Bordeaux	40 30 N	62 00 W	Aug. 20	7 p., 20	Aug. 22	29.84	NE.	NE, 7	SW.	NE, 9	NE-E-SSW.
West Cobalt, Am. S. S.	New Orleans	London	49 30 N	12 00 W	do	1 a., 20	Aug. 21	29.34	SSE.	SSE, 5	NW.	—, 10	SSE-S-NW.
Sulaco, Br. S. S.	Rotterdam	Jamaica	50 12 N	2 37 W	Aug. 21	7 a., 21	do	29.47	SSE.	SSW, 8	SW.	S, 9	S-SW.
San Benito, Br. S. S.	Tela, Honduras.	Boston	36 40 N	72 50 W	do	Mdt., 22	Aug. 23	29.62	NNE.	NNW, 10	NW.	NNW, 10	N-NW.
Chincha, Am. S. S.	Rio de Janeiro.	Baltimore	21 17 N	56 02 W	Aug. 22	2 a., 22	do	29.70	SSW.	SSW, 10	E.	—, 10	SSW-S-E.
Viborg, Dan. S. S.	Cuba	New York	35 15 N	74 05 W	do	4 p., 22	do	29.17	S.	NNW, 10	NW.	NNW, 10	NE-NNW.
Schenectady, Am. S. S.	Copenhagen	Portland, Me	55 25 N	34 06 W	Aug. 23	7 a., 23	Aug. 24	29.54	W.	WNW, 7	WNW.	NW, 9	W-NW.
Chincha, Am. S. S.	Rio de Janeiro.	Baltimore	27 13 N	63 16 W	Aug. 25	Noon, 25	Aug. 26	28.36	NE.	—, 10	SW.	NE, 12	NE-SW.
Endicott, Am. S. S.	Galveston	Havre	38 50 N	62 32 W	Aug. 27	3 p., 27	Aug. 29	28.70	ENE.	N., 12	NW.	—, 12	ENE-N-NNW.
Reliance, Ger. S. S.	New York	Hamburg	40 58 N	57 15 W	do	7 a., 28	Aug. 28	28.89	ENE.	N., 12	NNW.	N, 12	NE-N.
President Wilson, Am. S. S.	Gibraltar	New York	41 30 N	48 00 W	Aug. 28	6 p., 28	Aug. 29	28.67	S.	S, 12	N.	S, 12	S-W-N.
Paris, Fr. S. S.	Plymouth	do	41 18 N	53 06 W	do	11 a., 28	Aug. 28	28.49	SSW.	SW, 12	N.	SW, 12	
Steel Exporter, Am. S. S.	Avonmouth	Philadelphia	41 05 N	32 35 W	Aug. 29	2 p., 29	Aug. 30	29.37	S.	N, 12	N.	N, 12	
Effna, Am. S. S.	Rotterdam	Tampa	40 18 N	26 26 W	do	11 p., 29	do	29.48	SSW.	SW, 10	W.	SW, 12	SSW-SW.
West Hobomac, Am. S. S.	Avonmouth	New Orleans	39 04 N	30 04 W	do	6 p., 29	Aug. 29	29.40	SW.	SW, 9	WNW.	W, 11	SW-W.
Resolute, Ger. S. S.	Cherbourg	New York	48 27 N	22 50 W	do	—, 29	Aug. 31	29.42	SE.	ESE, 8	NE.	SE, 10	SE-E-NE.
West Kyska, Am. S. S.	Antwerp	Gulfport	41 17 N	22 55 W	do	4 a., 30	Aug. 30	28.77	S.	SW, 12	SW.	SW, 12	S-SW.
Iroquois, Br. S. S.	Thamesshaven.	Baton Rouge.	42 55 N	25 40 W	do	—, 30	Aug. 31	28.78	S.	SW, 8	NNW.	S, 10	
NORTH PACIFIC OCEAN													
Havre Maru, Jap. S. S.	Los Angeles	Yokohama	40 50 N	152 10 E	Aug. 8	3 a., 9	Aug. 9	29.41	NNE.	NNE, 8	N.	NNE, 8	NNE-N.
Triumph, Am. M. S.	Kelung	San Pedro	25 30 N	128 45 E	Aug. 9	6 a., 10	Aug. 11	29.00	N.	NW, 10	S.	NW, 11	NNW-WNW.
Do	do	do	42 30 N	172 00 E	Aug. 19	7 a., 19	Aug. 19	29.00	SE.	E, 12	SE.	E, 12	SE-E-ENE.
Pres. Monroe, Am. S. S.	Manila	San Francisco.	22 18 N	178 27 W	Aug. 18	8 a., 18	do	29.73	NE.	E, 9	E.	E, 10	NE-ESE.
Toyama Maru, Jap. S. S.	San Francisco.	Balboa	17 24 N	102 48 W	do	Mdt, 18	do	29.63	NNE.	ESE	S.	ESE, 9	NNE-ESE.
Ohioan, Am. S. S.	Los Angeles	New York	19 30 N	105 30 W	Aug. 19	9 a., 19	do	29.82	NE.	SE, 8	ESE.	SE, 9	NE-SE-ESE.
San Marcos, Am. S. S.	Balboa	San Pedro	15 30 N	99 32 W	Aug. 18	4 a., 18	Aug. 20	29.84	NE.	SE, 8	SSE.	S, 10	SE-S.
Stuart Dollar, Am. S. S.	Tabaco, P. I.	Los Angeles	44 37 N	167 07 E	Aug. 19	2 p., 19	do	29.08	SE.	SE, 8	SSE.	SE, 9	N-SE.
Pres. Jefferson, Am. S. S.	Yokohama	Honolulu	34 20 N	154 50 E	Aug. 21	5 a., 22	Aug. 22	29.28	N.	ESE, 10	SE.	ESE, 10	E-SE.
Do	do	do	32 18 N	160 00 E	Aug. 23	11 a., 24	Aug. 24	29.38	NE.	W, 6	SW.	NNW, 9	NW-SW.
Sylvan Arrow, Am. S. S.	San Francisco	Nagasaki	33 45 N	148 29 E	Aug. 19	4 a., 20	Aug. 20	29.80	ESE.	NE, 7	N.	N, 12	E-NE-N.
Courageous, Am. M. S.	Shanghai	San Pedro	41 40 N	141 15 E	Aug. 30	Noon, 30	Aug. 30	29.64	SSE.	S, 8	SSW.	S, 8	SE-SSW.
INDIAN OCEAN													
Fairfield City, Am. S. S.	Penang	Port Said	11 50 N	51 27 E	Aug. 11	8 a., 11	Aug. 11	29.74	SSW.	S, 8	S.	S, 8	SSW-S.
Do	do	do	12 48 N	45 00 E	Aug. 13	6 a., 13	Aug. 13	29.58	SW.	SW, 9	NW.	SW, 9	SW-W.
SOUTH ATLANTIC OCEAN													
M. F. Elliott, Am. S. S.	Talara, Peru	Santos, Brazil.	34 40 S	51 10 W	Aug. 21	7 p., 21	Aug. 21	29.58	ENE.	SSE, 10	NE.	SSE, 10	SSE-NE.

NORTH PACIFIC OCEAN

By WILLIS E. HURD

The North Pacific anticyclone, as in the preceding July, continued to dominate the weather of the upper two-thirds of the eastern half of the ocean; and, as in that month, it extended far up into the Bering Sea, entirely superceding the Aleutian LOW, except on a few days, the average pressure even at St. Paul being 30.04 inches, or 0.28 inch above the normal. Only on the lower slope of the HIGH was the barometer below the average, Honolulu slightly below, and Midway Island as much as 0.12 inch below. A slight depression lay over the western part of the Gulf of Alaska, but even there the barometer was higher than the average for the month.

The accompanying table gives the principal barometric data for several island and coast stations in west longitudes.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level at indicated hours, North Pacific Ocean and adjacent waters, August, 1930*

Stations	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Point Barrow [1] [2]	29.83		30.24	26th	29.50	14th.
Dutch Harbor [1] [3]	30.09	+0.19	30.46	13th	29.44	3d.
St. Paul [1] [3]	30.04	+0.28	30.44	13th	29.42	4th.
Kodiak [1] [3]	29.94	+0.09	30.36	27th	29.60	8th.
Midway Island [1] [4]	29.97	−0.12	30.16	4th [5]	29.84	15th.
Honolulu [6]	29.98	−0.03	30.08	7th	29.82	10th.
Juneau [6]	30.05	+0.03	30.30	26th	29.78	12th.
Tatoosh Island [6] [7]	30.06	+0.01	30.23	25th	29.82	14th.
San Francisco [6] [7]	29.98	+0.04	30.13	12th	29.83	31st.
San Diego [6] [7]	29.93	+0.04	30.09	12th	29.81	27th.

[1] P. m. observations only.
[2] For 29 days.
[3] For 30 days.
[4] For 28 days.
[5] And on the 6th.
[6] A. m. and p. m. observations.
[7] Corrected to 24-hour mean.

Comparatively few cyclones invaded the middle and higher latitudes of the North Pacific, along the well-traveled steamship routes, during August. Such few as did occur and occasioned winds of gale force were confined to the western half of the ocean and were partly of tropical origin. However, one of the severest gales of the month reported by one of our vessel observers, an east wind of hurricane velocity, accompanied by a barometer reading of 29 inches, was associated with a cyclone of the extra-tropics. It was encountered by the American motorship *Triumph* in latitude 42° 30′ N., longitude 172° E. On the same date other steamships experienced gales of force 9 at varying distances to the westward. On the 30th a fresh gale was reported in the vicinity of Hakodate, Japan.

Elsewhere is an account of the two typhoons of the month, by the Rev. José Coronas, S. J., of the Manila Observatory. One of the Weather Bureau's observing vessels, the *Triumph*, passed through the earlier typhoon on the 10th, experiencing a northwest gale of force 11, with a pressure of 29 inches, very close to the Nansei Islands. Another vessel, the American steamer *Sylvan Arrow*, passed through the second typhoon on the afternoon of the 19th and morning of the 20th, touching the outskirts of the central area, with a barometer of 28.80 inches, at 4 a. m. of the 20th, in 33° 45′ N., 148° 20′ E. Winds of hurricane force were encountered on both dates. On the 21st to 24th the American steamer *President Jefferson* ran into the fresh to whole gales of this cyclone between 30° and 35° N., 150° and 160° E. There are no observations of the storm farther to the eastward, but it is thus seen that the typhoon which was lost to observation of the Manila Observatory on the 18th can be carried forward from that date for at least six days.

On the 18th a whole east gale was reported in the upper tropic by the American steamer *President Monroe* at some distance south of Midway Island. The lowest barometer reading on the vessel was 29.73 inches. It would be extremely interesting to know if this gale were connected with a tropical cyclone traveling thus far to the eastward out of the beaten path of typhoons.

In the American Tropics there is evidence that a cyclone of some intensity occurred off the Mexican west coast on the 18th to 20th. The earliest reported observation of the storm comes from the American steamer *San Marcos*, which encountered a fresh southeast gale on the 18th about 100 miles south-southeast of Acapulco, followed by a whole southerly gale farther northward on the 19th. The lowest barometer reported was 29.63 inches, read on board the Japanese steamer *Toyama Maru* in 17° 24′ N., 102° 48′ W. at midnight of the 18th. The wind shifts experienced by the *San Marcos*, and also by the American steamer *Ohioan*, which encountered a gale of force 9 west of Manzanillo, point conclusively to the existence of a cyclone in these waters.

The prevailing wind at Honolulu during August was from the east, with a maximum velocity of 25 miles an hour from the same direction on the 11th.

Fog, while less continuously observed by vessels than in July, was nevertheless frequent along the central and western portions of the northern sailing routes and in the Bering Sea. Both north and south of the Aleutian Islands, and for some distance westward toward northern Japan, fog was observed on from 10 to 16 days. Along the American coast the strip of its greatest frequency, where it was reported as occurring on 13 days, lay off central California. Off Lower California it was reported on three days.

FIVE SEVERE TYPHOONS OVER THE FAR EAST IN JULY, 1930

By Rev. José CORONAS, S. J.

[Weather Bureau, Manila, P. I.]

The past month of July was very stormy in the Far East. Prescinding from other depression or typhoon centers of less importance, we will mention here only five of them as the most important and of greatest intensity.

Formosa and China typhoon, July 9 to 17.—The first part of this typhoon is rather indefinite until 6 a. m. of the 11th when the center was shown in our weather map about 100 miles to the southeast of Basco, Batanes Islands, moving west-northwest or northwest by west. From 2 p. m. of the same day it took a decided northerly direction very near to the east of Basco, where the barometric minimum 29.35 inches (745.4 mm.) was recorded at 8 p. m. with winds from northwest. The center passed close to or over the northeastern end of Formosa in the early hours of the 13th, the barometer of Taihoku having fallen to 29.17 inches (741.0 mm.) at 5 a. m.

The steamers *Empress of Russia*, *President Jackson*, and *Tjisondari* were well under the influence of this typhoon very near the northern part of Formosa Channel.

From Formosa the typhoon moved northwestward until 6 a. m. of the 14th, when it began to move northward again along eastern China not far from the coast. On the 15th it recurved northeastward toward north-

western Korea, where it probably filled up gradually on the 17th.

The approximate positions of the center at 6 a. m. of July 11 to 16 were as follows:

July 11, 6 a. m. 123° 05′ longitude E., 19° 15′ latitude N.
July 12, 6 a. m. 122° 20′ longitude E., 21° 45′ latitude N.
July 13, 6 a. m. 121° 30′ longitude E., 25° 30′ latitude N.
July 14, 6 a. m. 119° 00′ longitude E., 27° 00′ latitude N.
July 15, 6 a. m. 117° 30′ longitude E., 33° 20′ latitude N.
July 16, 6 a. m. 122° 20′ longitude E., 40° 30′ latitude N.

The Korea typhoon, July 18 and 19.—The first part of this typhoon is also indefinite owing to lack of observations from the Pacific between Guam and the Philippines. It seems probable, however, that after moving west-northwest for some days, it recurved to north and north-northeast on the 15th about 200 miles to the east of Balintang Channel. The center was situated at 6 a. m. of the 16th about 150 miles to the south of Naha, Loochoo Islands. From that time it moved practically northward until it probably filled up on the 20th over Manchuria.

The storm was severely felt in southwestern Japan and Korea. The following information was given by the United Press:

SEOUL, KOREA, July 21.—Figures compiled here to-day showed how great was the force of the typhoon which last week devastated wide areas in Kyushiu and Korea.

The dead are officially listed as numbering 349.

Injured persons total 201 while 1,386 persons are listed as missing.

No less than 7,812 houses have been destroyed. There are 35,220 homes and buildings flooded.

It is feared that the extent of the storm damage will prove to be even greater as additional reports are received through Government channels.

Several steamships which reported themselves in distress during the typhoon have not been heard from. It is feared they may have foundered. Large numbers of vessels in the fishing fleets are listed as lost.

The steamer *Aki Maru* was very near the center in 128° 20′ longitude E. and 31° 45′ latitude N; she reported a barometric minimum as low as 27.97 inches (710.4 mm.) at 2:55 a. m. of the 18th and hurricane winds from the north and northwest quadrants.

A Luzon typhoon, July 22 and 23.—This typhoon seems to have formed very far over the Pacific near 150° longitude E, and 12° or 13° latitude N., although lack of observations between Guam and the Philippines prevent us from giving as certain the track of this typhoon until it was clearly shown on our weather map for 2 p. m. of the 21st in about 128° longitude E. and near 15° latitude N. moving west by north. The center reached Luzon and passed about 60 miles to the north of Manila during the night of July 22–23. Once in the China Sea the typhoon moved northwestward, and reached the China coast to the west of Hong Kong in the evening of the 24th.

The steamers *Silverguava, Tjisondari, Taiping,* and *Aki Maru* were much involved in this typhoon on the 23d and 24th to the west of central and northern Luzon.

The lowest barometric minimum reported by our stations was that of Baler; it was 29.32 inches (744.65 mm.) at 10 p. m. of the 22d with winds from southeast, force 8.

The approximate positions of the center at 6 a. m. of July 22 to 25 were as follows:

July 22, 6 a. m. 125° 00′ longitude E, 15° 25′ latitude N.
July 23, 6 a. m. 119° 05′ longitude E, 16° 15′ latitude N.
July 24, 6 a. m. 116° 00′ longitude E, 19° 05′ latitude N.
July 25, 6 a. m. 110° 00′ longitude E, 23° 40′ latitude N.

The Loochoos typhoon, July 24 to 29.—This severe typhoon was probably formed on the 24th to the south of the Bonins near 143° longitude E. 20° or 21° latitude N. It moved west-northwest until it reached Naha, when it took a due west direction toward China. The barometric reading at Naha at noon of the 27th was as low as 28.31 inches (719 mm.), the winds blowing with hurricane force from the north quadrant.

The U. S. S. *Barker* was well under the influence of this typhoon over the Formosa Channel on the 29th.

The approximate positions of the center at 6 a. m. of July 24 to 29 were:

July 24, 6 a. m. 143° 20′ longitude E, 20° 30′ latitude N.
July 25, 6 a. m. 137° 00′ longitude E, 22° 50′ latitude N.
July 26, 6 a. m. 131° 30′ longitude E, 24° 15′ latitude N.
July 27, 6 a. m. 127° 45′ longitude E, 25° 35′ latitude N.
July 28, 6 a. m. 123° 15′ longitude E, 25° 55′ latitude N.
July 29, 6 a. m. 118° 50′ longitude E, 26° 00′ latitude N.

A very distant Pacific typhoon, July 24 to 30.—This typhoon was of no importance for the Philippines. It probably formed on the 24th to the east of Guam, and on the 25th and 26th it recurved gradually to the north and northeast. The center passed not far east of the Bonins in the afternoon of the 29th.

TWO SEVERE TYPHOONS OVER THE PACIFIC IN AUGUST, 1930

By Rev. José CORONAS, S. J.

[Weather Bureau, Manila, P. I.]

There has been no typhoon over the Philippines during this month of August. And even over the Pacific there have been only two very severe typhoons. One over the Loochoos and southwestern Japan and another over the Bonins.

The typhoon of the Loochoos and southwestern Japan; August 5 to 14.—The place of origin of this typhoon is still uncertain owing to lack of sufficient observations up to the present. The center seems to have remained almost stationary on the 5th and the morning of the 6th to the north-northwest of Guam in about 144° longitude E and 15° latitude N. After 2 p. m. of the 6th and during the 7th and 8th it moved northwest by west; on the 9th it inclined decidedly to the north; on the 10th to 13th it kept an almost due north direction; finally it recurved northeastward on the 13th in the neighborhood of Korea. The lowest barometric reading reported was 28.27 inches (718 mm.) at 6 a. m. of the 11th from the station of Oshima in the northern part of the Loochoo Islands.

The approximate positions of the center at 6 a. m. of August 5th and 6th, 7th, 8th, 9th, 10th, 11th; 12th and 14th are as follows; the position at 6 a. m. of the 13th is omitted as somewhat doubtful owing to lack of observations:

August 5 and 6, 6 a. m. 143° 55′ longitude E, 15° 10′ latitude N.
August 7, 6 a. m. 140° 15′ longitude E, 17° 45′ latitude N.
August 8, 6 a. m. 136° 05′ longitude E, 20° 30′ latitude N.
August 9, 6 a. m. 130° 50′ longitude E, 24° 30′ latitude N.
August 10, 6 a. m. 129° 30′ longitude E, 26° 35′ latitude N.
August 11, 6 a. m. 129° 30′ longitude E, 28° 35′ latitude N.
August 12, 6 a. m. 129° 30′ longitude E, 31° 20′ latitude N.
August 14, 6 a. m. 132° 20′ longitude E, 41° 15′ latitude N.

The Bonins typhoon, August 16 to 18.—Lack of sufficient weather reports prevents us from giving the track of this typhoon prior to the 16th. At 6 a. m. of the 16th the center of a severe typhoon was shown in our weather map to the southwest of the Bonins in about 23° latitude N., between 137° and 138° longitude E. It moved northeast on the 16th, and north-northeast on the 17th passing close to the Bonin Islands in the morning of the 17th, the barometric reading there at 6 a. m. having been

much lower than 28.74 inches (730 mm.), although we can not give the exact figures owing to a possible error in the telegraphic transmission. The barometric reading reported at noon was still as low as 28.70 inches (729 mm.) (gravity correction applied).

The approximate positions of the center at 6 a. m. of the 16th, 17th, and 18th were as follows:

August 16, 6 a. m. 137° 30′ longitude E, 22° 45′ latitude N.
August 17, 6 a. m. 141° 30′ longitude E, 26° 40′ latitude N.
August 18, 6 a. m. 144° 15′ longitude E, 30° 55′ latitude N.

CLIMATOLOGICAL TABLES

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatologicl service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, August, 1930

[For description of tables and charts, see REVIEW, January, 1930, p. 37]

Section	Temperature								Precipitation					
	Section average	Departure from the normal	Monthly extremes						Section average	Departure from the normal	Greatest monthly		Least monthly	
			Station	Highest	Date	Station	Lowest	Date			Station	Amount	Station	Amount
	°F.	°F.		°F.			F°.		In.	In.		In.		In.
Alabama	79.5	−0.1	2 stations	108	17	Valley Head	50	124	3.50	−1.04	Prattville	9.48	Tallassee	1.57
Arizona	79.4	−0.3	----do	116	27	Williams	35	19	2.21	+0.07	Snowflake	6.35	2 stations	0.00
Arkansas	81.8	+2.1	----do	114	9	Dutton	46	26	2.58	−1.11	Searcy	7.93	Blytheville	0.23
California	71.0	−1.1	Greenland Ranch	118	11	Portola	25	20	0.08	−0.02	Palm Springs	2.03	128 stations	0.00
Colorado	65.8	+0.7	Lamar	104	3	Hermit	26	31	3.14	+1.18	Cope	9.74	Fruita	0.33
Florida	80.6	−0.8	Blountstown	103	4	Penney Farms	55	25	4.34	−2.68	Moore Haven	11.61	Fernandina	0.35
Georgia	78.6	−0.8	Tallapoosa	105	6	Clayton	44	123	1.90	−3.32	Waycross	4.50	Savannah (No. 2)	0.13
Idaho	68.5	+2.3	Orofino	111	8	Stibnite	22	30	1.30	+0.58	Malad	5.40	St. Maries	0.00
Illinois	76.2	+2.0	2 stations	113	9	Danville	45	11	1.96	−1.50	Aledo	8.55	Chester	0.10
Indiana	74.4	+1.1	6 stations	108	17	2 stations	40	112	2.07	−1.24	Huntington	5.71	Albion	0.87
Iowa	74.4	+2.7	Sac City	113	3	3 stations	41	111	2.42	−1.02	Storm Lake	6.71	Washta	0.48
Kansas	79.7	+2.3	4 stations	114	13	Atwood	51	26	2.81	−0.24	Plainville	8.91	Coldwater	0.40
Kentucky	76.5	+0.9	St. John	113	15	Farmers	42	12	2.25	−1.48	Flemingsburg	5.40	Murray	0.32
Louisiana	81.8	+0.1	Dodson	108	15	St. Joseph	53	22	4.63	−0.56	Delta Farms	14.72	Dodson	0.45
Maryland-Delaware	73.8	+0.5	Keedysville, Md	108	4	Oakland, Md	30	12	1.12	−3.15	Millington, Md	3.33	Ferry Landing, Md	0.15
Michigan	68.6	+2.1	Monroe	102	2	2 stations	28	111	0.75	−2.07	Owosso	2.20	Alcona	0.05
Minnesota	70.8	+4.3	Fairmont	109	3	Meadowlands	33	110	1.09	−2.11	Waseca	4.50	Big Falls	0.15
Mississippi	81.0	+0.4	Corinth	110	8	Fayette	52	22	3.22	−1.14	Pearlington	8.60	Greenville	0.13
Missouri	78.5	+2.5	2 stations	114	9	Steffenville	47	11	2.02	−1.73	Maryville	4.81	Valley Park	0.04
Montana	68.7	+4.2	Trout Creek	105	9	Philipsburg	24	31	1.02	−0.11	Hebgen Dam	4.40	Melstone	0.11
Nebraska	74.6	+1.7	2 stations	113	3	Ainsworth	44	29	4.15	+1.33	Fairmont	10.64	Springview	1.17
Nevada	70.5	−0.1	Logandale	111	6	Zora Vista Ranch	25	20	0.80	+0.36	Arthur	2.93	Mina	0.00
New England	66.2	−0.6	2 stations	100	3	Bloomfield, Vt	32	14	2.54	−1.33	Van Buren, Me	6.14	Hardwick, Mass	0.85
New Jersey	71.1	−0.7	----do	101	13	Layton	34	13	3.32	−1.61	Woodcliff Lake	5.58	Cape May City	1.92
New Mexico	70.4	+0.6	----do	107	14	Therma	31	20	2.15	−0.34	Cloverdale	5.74	Newman	0.21
New York	67.4	+0.1	Addison	103	8	Allegany State Park	32	112	2.41	−1.41	South Edwards	5.38	Elmira	0.50
North Carolina	73.9	−1.4	Weldon	105	10	Banners Elk	31	23	2.68	−2.72	Statesville	6.06	Henderson	0.23
North Dakota	70.4	+5.0	2 stations	104	12	Portal	32	31	1.45	−0.83	Ellendale	5.01	Pembina	T.
Ohio	72.0	+0.4	3 stations	107	4	3 stations	38	112	2.35	−1.00	St. Paris	5.32	Put-in-Bay	0.58
Oklahoma	83.8	+2.6	Alva	113	3	2 stations	54	125	1.81	−1.25	Tuskahoma	4.11	Walters	0.21
Oregon	66.7	+1.5	Umatilla	109	17	Sand Creek	23	124	0.22	−0.29	Olive Lake	1.60	15 stations	0.00
Pennsylvania	70.3	+0.3	Carlisle	108	4	Somerset	29	12	1.47	−2.76	Kregar	4.12	Sunbury	0.29
South Carolina	77.5	−1.3	2 stations	103	16	Caesar's Head	46	23	2.42	−3.33	Georgetown	7.66	Trenton	0.29
South Dakota	74.2	+4.3	Wagner	113	2	Hot Springs	42	31	2.80	+0.42	Dowling	8.24	Waters Ranch	0.18
Tennessee	77.4	+1.0	Perryville	113	9	Crossville	43	12	2.61	−1.40	Kingsport	6.11	McKenzie	0.40
Texas	84.1	+1.4	McKinney	114	19	4 stations	53	18	1.51	−1.05	Navasota	6.79	16 stations	0.00
Utah	69.8	+0.3	St. George	104	16	Park City	30	9	2.57	+1.37	Black's Fork (near)	6.70	Bluff	0.34
Virginia	74.2	+0.6	3 stations	107	14	Burkes Garden	36	112	1.75	−2.66	Mendota	5.85	Randolph	0.15
Washington	67.4	+1.9	Wahluke	110	12	3 stations	32	126	0.22	−0.70	Forks	1.64	11 stations	0.00
West Virginia	70.7	−1.1	Moorefield	112	4	2 stations	30	12	2.20	−1.90	Gary	5.07	Upper Tract	0.70
Wisconsin	70.0	+3.1	2 stations	103	3	Big St. Germain Dam.	31	12	1.05	−2.23	Lake Mills	3.18	Downing	0.10
Wyoming	65.3	+1.3	Colony	100	1	Riverside	28	30	3.24	+2.26	Pinebluff	9.44	Ulm	T.
Alaska (July)	55.7	−0.1	Fort Yukon	84	27	Barrow	28	24	2.70	−0.06	Mount Roberts (b)	14.91	Fort Yukon	0.42
Hawaii	76.2	+1.0	Kaanapali	96	121	Waimea	51	16	9.30	+2.03	Pihonua	59.83	2 stations	0.00
Porto Rico	79.8	+0.7	Juana Diaz	101	11	Guineo Reservoir	50	15	4.99	−2.24	Lares	15.95	Santa Isabel	1.41

TABLE 1.—*Climatological data for Weather Bureau stations, August, 1930*

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with .01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0–10	In.	In.
New England							67.3	−0.1										78	2.10	−1.5										5.3		
Eastport	76	67	85	29.92	30.00	+0.04	60.6	−0.1	79	27	68	49	13	53	27	56	54	83	2.32	−0.7	8	5,058	s.	33	e.	23	2	12	17	7.2	0.0	0.0
Greenville, Me.	1,070	6	----	28.86	30.01	----	61.4	----	81	28	71	39	14	52	30	----	----	----	4.24	----	13	3,299	sw.	----	----	----	9	11	11	----	0.0	0.0
Portland, Me.	103	82	117	29.90	30.02	+.04	65.6	−0.8	86	5	73	48	13	59	22	60	56	75	2.62	−0.5	13	4,726	sw.	30	ne.	23	10	15	6	4.6	0.0	0.0
Concord	289	70	79	29.70	30.00	+.02	65.7	−1.1	91	3	77	41	13	55	34	----	----	----	2.82	−0.7	10	2,821	nw.	22	e.	23	12	9	10	5.4	0.0	0.0
Burlington	403	11	48	29.56	29.98	+.01	65.6	−2.3	85	28	76	43	13	56	31	----	----	----	1.61	−1.8	15	4,947	s.	24	sw.	24	8	8	15	6.2	0.0	0.0
Northfield	876	12	60	----	30.02	+.04	62.6	−0.8	86	4	75	36	13	50	36	----	----	84	1.17	−2.4	12	3,306	s.	25	sw.	4	2	20	9	6.5	0.0	0.0
Boston	125	106	165	29.87	30.00	+.01	70.5	+0.6	98	3	78	53	12	63	28	63	59	70	3.03	−0.6	8	4,472	sw.	20	e.	23	8	18	5	5.2	0.0	0.0
Nantucket	12	14	90	29.99	30.00	+.01	68.4	+0.6	90	5	75	57	13	62	21	64	62	85	1.79	−1.6	7	8,430	sw.	36	ne.	23	16	8	7	4.5	0.0	0.0
Block Island	26	11	46	29.96	29.99	.00	69.2	+0.7	88	5	75	57	12	64	19	65	63	86	2.29	−1.4	7	8,300	sw.	48	ne.	23	10	16	5	4.9	0.0	0.0
Providence	160	215	251	29.83	30.00	+.01	70.6	−0.4	97	3	80	52	13	62	25	63	59	71	2.14	−1.4	7	6,115	nw.	48	nw.	16	15	12	4	4.1	0.0	0.0
Hartford	159	122	----	29.84	30.01	+.02	70.5	+1.6	98	3	80	50	13	60	29	----	----	----	1.92	−2.4	9	----	s.	----	----	----	12	12	7	4.5	0.0	0.0
New Haven	106	74	153	29.89	30.00	+.01	70.7	+0.4	94	3	80	51	13	62	24	64	60	72	1.35	−2.9	8	5,394	s.	37	n.	23	12	12	7	4.8	0.0	0.0
Middle Atlantic States							73.6	+0.2										68	1.80	−2.5										4.8		
Albany	97	107	115	29.89	29.99	+.01	70.8	0.0	95	3	81	49	13	61	30	63	60	74	2.20	−1.5	10	3,776	s.	22	sw.	29	13	13	5	4.2	0.0	0.0
Binghamton	871	10	84	29.10	30.02	+.03	69.0	+1.0	97	4	81	40	13	56	40	----	----	----	1.54	−2.0	8	2,879	ne.	18	nw.	9	6	12	13	6.5	0.0	0.0
New York	314	414	454	29.67	30.00	.00	72.8	−0.3	93	5	80	55	23	66	20	64	60	71	3.43	−0.9	9	7,704	sw.	48	n.	23	7	16	8	5.5	0.0	0.0
Bellefonte	1,050	5	36	28.92	30.02	----	68.1	----	100	4	84	37	12	53	43	59	53	62	0.36	----	4	----	sw.	----	----	----	9	11	11	5.8	0.0	0.0
Harrisburg	374	94	104	29.62	30.01	.00	74.0	+1.4	103	4	85	50	13	63	32	62	54	56	1.21	−2.8	6	3,458	nw.	18	sw.	4	10	16	5	5.0	0.0	0.0
Philadelphia	114	123	367	29.89	30.01	+.01	75.7	+0.9	98	5	84	57	23	67	23	65	59	63	1.51	−3.1	8	7,655	sw.	35	ne.	23	9	16	6	5.1	0.0	0.0
Reading	325	81	98	29.66	30.00	----	73.8	+1.4	99	5	84	51	13	63	30	63	57	61	1.21	−3.0	6	3,144	sw.	17	nw.	10	14	8	9	4.9	0.0	0.0
Scranton	805	111	119	29.17	30.02	+.02	70.2	+0.4	98	4	82	42	13	58	37	60	55	63	1.85	−1.8	5	3,522	sw.	24	ne.	23	10	19	2	4.6	0.0	0.0
Atlantic City	52	37	172	29.94	29.99	−.01	72.2	−0.3	92	10	78	56	13	66	22	67	64	79	2.55	−1.9	5	9,243	s.	48	n.	23	14	11	6	4.2	0.0	0.0
Cape May	17	13	49	----	----	----	72.0	−1.4	92	9	80	53	13	64	23	67	65	81	1.92	−2.3	6	----	s.	----	----	----	12	13	6	----	0.0	0.0
Sandy Hook	22	10	55	29.96	29.98	----	72.6	----	94	5	79	57	23	66	20	66	62	75	2.94	−2.0	5	7,930	sw.	56	ne.	23	14	10	7	4.6	0.0	0.0
Trenton	190	159	183	29.80	30.00	----	72.8	−0.2	95	9	83	53	12	63	28	64	59	68	3.30	−1.4	7	5,640	sw.	44	ne.	23	11	15	5	4.9	0.0	0.0
Baltimore	123	100	215	29.87	29.99	−.02	77.6	+2.1	104	5	87	60	12	68	29	65	59	56	0.78	−3.6	6	6,099	n.	28	sw.	29	10	17	4	4.9	0.0	0.0
Washington	112	62	85	29.89	30.00	−.01	76.8	+1.8	102	5	88	55	13	66	30	64	58	59	0.62	−3.4	5	3,252	nw.	20	nw.	10	10	15	6	4.6	0.0	0.0
Cape Henry	18	8	54	29.98	30.00	----	75.4	−1.5	96	4	82	60	24	68	23	69	66	77	1.88	−3.0	6	7,070	sw.	34	n.	17	15	11	5	4.6	0.0	0.0
Lynchburg	681	153	188	29.31	30.04	+.02	75.4	−0.2	101	9	88	49	13	63	34	64	58	60	0.42	−3.4	9	3,599	n.	26	sw.	17	13	14	4	4.7	0.0	0.0
Norfolk	91	170	205	29.92	30.02	+.02	77.4	0.0	100	9	86	60	24	69	25	68	64	71	0.64	−4.6	6	7,123	ne.	32	ne.	21	12	9	10	4.7	0.0	0.0
Richmond	144	11	52	29.87	30.01	.00	76.1	−0.4	101	9	88	55	13	65	30	66	62	69	2.35	−2.1	6	3,731	sw.	31	n.	27	16	8	7	4.0	0.0	0.0
Wytheville	2,304	49	55	27.72	30.03	+.02	68.6	−1.9	93	5	81	44	13	56	34	60	56	71	2.13	−2.1	9	2,930	w.	16	w.	10	14	11	6	4.4	0.0	0.0
South Atlantic States							77.3	−0.8										73	2.13	−3.6										4.4		
Asheville	2,253	70	84	27.76	30.05	+.03	70.4	−0.1	94	8	82	49	23	59	31	61	58	75	1.78	−2.4	8	3,352	se.	32	nw.	10	19	8	4	3.8	0.0	0.0
Charlotte	779	55	62	29.21	30.03	+.01	76.7	−0.4	100	5	88	53	23	66	30	66	62	68	3.41	−1.7	10	2,379	ne.	23	w.	10	12	12	7	4.8	0.0	0.0
Greensboro	886	5	56	29.10	30.04	----	74.2	----	101	5	87	51	24	61	38	65	63	76	2.25	----	9	4,109	sw.	31	ne.	7	12	12	7	4.7	0.0	0.0
Hatteras	11	5	50	29.99	30.00	.00	76.7	−1.3	87	6	82	62	24	71	19	71	68	78	3.07	−2.7	7	8,491	sw.	36	n.	22	14	11	6	4.3	0.0	0.0
Raleigh	376	103	110	29.62	30.01	.00	76.0	−1.0	98	9	86	58	21	66	28	67	62	68	1.25	−4.2	6	4,655	sw.	28	w.	9	12	12	7	4.5	0.0	0.0
Wilmington	78	81	91	29.95	30.03	+.03	76.7	−0.9	95	30	85	57	23	68	26	70	68	80	1.56	−4.8	7	3,906	sw.	15	ne.	13	11	12	8	4.9	0.0	0.0
Charleston	48	11	92	29.98	30.03	+.02	79.6	−1.4	94	29	86	62	23	73	22	72	70	78	1.75	−4.8	6	6,154	sw.	26	n.	8	12	12	7	4.4	0.0	0.0
Columbia, S. C.	351	41	57	29.66	30.03	+.02	78.0	−1.6	97	6	88	55	23	68	30	68	64	68	1.59	−3.9	7	3,453	ne.	24	nw.	18	13	14	4	4.1	0.0	0.0
Due West	711	10	55	29.30	30.05	----	77.5	----	96	31	88	53	23	66	37	----	----	----	0.78	----	5	4,307	sw.	24	se.	21	11	16	4	4.1	0.0	0.0
Greenville, S. C.	1,039	139	146	28.96	30.03	----	77.0	+1.2	98	5	87	54	23	67	26	67	62	67	2.65	−2.8	7	4,113	ne.	32	w.	5	8	17	6	4.9	0.0	0.0
Augusta	182	62	77	29.82	30.01	.00	79.4	−1.0	98	29	90	58	23	69	34	69	65	69	3.67	−1.4	8	2,921	s.	24	n.	21	14	14	3	4.4	0.0	0.0
Savannah	65	150	194	29.95	30.02	+.01	79.8	−0.9	97	29	89	60	23	71	28	72	69	78	1.95	−5.4	6	6,303	n.	32	nw.	11	12	12	7	4.3	0.0	0.0
Jacksonville	43	209	245	29.98	30.03	+.02	79.8	−1.9	95	6	87	64	22	72	21	72	69	76	0.76	−5.0	5	6,174	ne.	25	s.	7	14	12	5	4.4	0.0	0.0
Florida Peninsula							82.6	+0.5										75	5.31	−0.9										4.8		
Key West	22	10	64	29.98	30.00	+.02	83.8	+0.3	92	12	89	73	22	78	17	76	74	73	4.09	−0.4	14	4,702	e.	31	n.	19	10	13	8	5.2	0.0	0.0
Miami	25	124	168	30.00	30.02	−.01	82.4	+1.0	92	21	89	71	26	76	18	75	73	76	4.72	−1.4	16	4,990	ne.	25	w.	19	3	23	5	6.0	0.0	0.0
Tampa	35	79	197	29.98	30.01	+.01	81.6	+0.1	94	15	90	67	2	73	22	73	70	75	7.13	−1.0	14	5,645	e.	44	ne.	2	7	18	6	5.3	0.0	0.0
Titusville	44	5	----	29.97	30.03	----	81.8	----	99	10	91	66	22	72	26	----	----	----	5.65	----	8	----	sw.	----	----	----	23	6	2	2.7	0.0	0.0
East Gulf States							80.0	+0.1										71	3.38	−1.9										4.7		
Atlanta	1,173	190	216	28.83	30.04	+.03	78.8	+1.8	98	6	88	57	22	70	22	66	61	61	0.96	−3.5	8	4,613	nw.	23	nw.	17	11	11	9	5.0	0.0	0.0
Macon	370	78	87	29.64	30.03	+.02	78.6	−1.3	98	6	90	58	22	68	32	69	66	70	1.71	−2.6	6	3,013	sw.	21	nw.	10	13	12	6	4.1	0.0	0.0
Thomasville	273	49	108	29.74	30.03	+.03	79.6	−1.4	94	12	90	62	21	70	25	71	68	74	2.99	−2.8	6	3,640	ne.	30	w.	8	11	13	7	5.0	0.0	0.0
Apalachicola	36	11	51	29.98	30.02	----	80.6	----	92	8	88	67	26	74	20	73	71	73	2.68	−4.9	8	4,278	n.	28	nw.	19	15	13	3	4.1	0.0	0.0
Pensacola	56	149	185	29.97	30.03	+.05	79.6	−1.3	90	6	86	67	22	73	21	73	70	75	1.06	−7.0	7	6,361	w.	33	n.	18	8	11	12	5.8	0.0	0.0
Anniston	741	9	57	29.27	30.05	+.06	77.7	+1.3	103	8	90	55	23	65	36	----	----	----	1.99	−2.1	9	2,165	nw.	18	nw.	17	20	8	3	3.4	0.0	0.0
Birmingham	700	11	48	29.29	30.04	+.05	79.8	+0.6	103	8	91	59	23	68	31	68	64	69	4.93	+0.7	9	3,091	n.	17	ne.	20	14	11	6	4.3	0.0	0.0
Mobile	57	125	161	29.97	30.03	+.05	81.2	+0.2	95	13	90	65	23	73	23	73	71	78	3.71	−3.2	7	4,826	n.	38	sw.	18	7	16	8	5.6	0.0	0.0
Montgomery	223	100	112	29.80	30.04	+.05	80.2	−0.6	99	6	90	62	23	71	27	70	67	72	3.96	−0.3	8	3,162	sw.	26	sw.	10	11	10	10	5.4	0.0	0.0
Corinth	469	6	----	----	----	----	81.2	----	110	8	95	56	24	67	42	----	----	----	3.21	----	7	----	sw.	----	----	----	11	20	0	----	0.0	0.0
Meridian	375	87	95	29.64	30.02	+.04	79.4	−0.1	99	7	90	59	23	68	33	69	65	68	3.73	−0.8	9	2,798	sw.	27	n.	19	11	16	4	4.4	0.0	0.0
Vicksburg	247	65	73	29.76	30.04	+.06	82.2	+1.4	99	7	92	62	23	72	26	70	65	65	3.41	0.0	7	3,716	se	26	w.	18	16	11	4	3.7	0.0	0.0
New Orleans	53	76	84	29.97	30.02	+.04	82.8	+0.6	96	7	90	70	29	75	19	75	72	77	9.49	+3.7	9	2,832	se.	16	ne.	15	10	15	6	5.1	0.0	0.0
West Gulf States							84.0	+2.1										66	1.58	−1.4										3.8		
Shreveport	249	77	93	29.72	29.98	+.01	84.4	+2.4	102	19	96	67	23	73	28	72	66	62	2.40	−0.3	7	3,542	se.	22	nw.	20	17	8	6	4.0	0.0	0.0
Bentonville	1,303	11	44	28.64	29.97	.00	79.2	+2.7	102	13	92	55	23	66	34	----	----	----	2.62	----	5	2,420	s.	16	s.	4	28	2	1	----	0.0	0.0
Fort Smith	457	79	94	29.50	29.97	.00	84.8	+4.3	106	7	97	62	23	72	31	69	63	55	0.95	−2.3	4	3,912	e.	28	se.	4	10	16	5	4.9	0.0	0.0
Little Rock	357	136	153	29.63	30.00	+.02	82.8	+3.0	105	8	94	69	23	72	29	68	60	53	0.65	−3.1	6	4,586	e.	28	sw.	4	19	7	5	3.8	0.0	0.0
Austin	605	136	148	29.34	29.97	----	85.2	+1.4	103	20	97	67	28	74	28	72	66	62	1.71	−0.3	5	4,587	s.	29	se.	5	19	11	1	3.6	0.0	0.0
Brownsville	57	83	100	29.91	29.97	----	83.8	−0.1	96	21	92	71	28	76	23	75	72	77	0.53	−2.0	2	6,984	se.	26	se.	31	21	9	1	2.9	0.0	0.0
Corpus Christi	20	11	78	29.96	29.98	+.05	84.0	+1.5	97	29	91	73	28	77	23	76	74	80	0.32	−2.0	1	7,914	se.	26	se.	10	18	9	4	3.6	0.0	0.0
Dallas	512	220	227	29.44	29.97	----	84.9	----	104	19	95	68	26	75	28	----	----	----	1.21	−1.6	5	6,258	s.	34	ne.	22	24	5	2	2.4	0.0	0.0
Fort Worth	670	106	114	29.26	29.96	+.02	85.2	+2.2	105	19	96	67	5	74	28	70	63	54	3.12	+0.5	8	4,979	se.	21	w.	5	11	13	7	4.9	0.0	0.0
Galveston	54	106	114	29.97	30.03	+.07	83.4	+0.4	92	1	88	67	25	78	17	76	73	76	2.73	−1.6	5	6,375	s.	33	se.	25	11	17	3	4.7	0.0	0.0
Groesbeck	461	11	56	29.51	29.98	----	84.2	----	103	19	96	64	29	73	30	----	----	----	1.50	−0.4	6	5,458	s.	22	se.	31	17	10	4	3.3	0.0	0.0
Houston	138	292	314	29.86	30.00	----	85.2	+2.0	102	19	95	69	29	76	25	----	----	----	0.79	−3.4	7	6,132	s.	26	e.	1	13	15	3	4.5	0.0	0.0
Palestine	510	64	72	29.48	29.99	+.02	83.4	+1.6	103	19	94	67	29	73	29	71	67	66	2.10	−0.1	6	3,871	s.	22	s.	31	18	8	5	3.4	0.0	0.0
Port Arthur	34	58	66	29.97	30.01	----	83.6	----	97	1	92	69	27	75	27	75	72	75	3.88	−2.1	9	4,356	e.	33	e.	19	16	12	3	3.8	0.0	0.0
San Antonio	693	242	301	29.26	29.95	+.02	85.8	+2.3	103	20	98	70	27	74	28	72	67	63	0.41	−2.0	1	6,583	se.	34	se.	31	16	13	2	3.4	0.0	0.0
Taylor	571	38	51	29.42	30.01	+.06	84.8	+3.1	102	19	97	68	25	73	28	----	----	----	1.35	−1.0	3	4,915	s.	26	se.	31	15	13	3	3.7	0.0	0.0

TABLE 1.—*Climatological data for Weather Bureau stations, August, 1930*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean maximum - Minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with .01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
Ohio Valley and Tennessee	*Ft.*	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	*°F.*	*°F.*	*°F.*		*°F.*	*°F.*		*°F.*	*°F.*	*°F.*	*°F.*	*%*	*In.*	*In.*		*Miles*								*0–10*	*In.*	*In.*
							75.5	+0.6										60	1.97	−1.4										5.0		
Chattanooga	762	190	215	29.22	30.01	+.01	77.8	+0.3	98	9	88	55	22	67	30	66	60	60	1.43	−2.6	7	4,059	sw.	30	sw.	9	8	20	3	5.0	0.0	0.0
Knoxville	995	102	111	29.00	30.03	+.02	76.5	+0.3	101	8	88	54	23	65	35	65	60	64	2.03	−1.9	7	3,086	ne.	24	sw.	8	13	10	8	4.7	0.0	0.0
Memphis	399	76	97	29.59	30.00	+.02	81.4	+2.0	104	8	91	62	24	71	33	68	61	56	0.49	−2.9	4	4,299	ne.	20	nw.	17	16	10	5	3.9	0.0	0.0
Nashville	546	168	191	29.46	30.04	+.04	79.2	+1.4	105	9	90	58	22	68	34	65	58	56	4.69	+1.0	8	4,712	w.	26	sw.	4	16	11	4	3.7	0.0	0.0
Lexington	989	193	230	29.01	30.05	+.04	76.2	+1.7	99	8	86	56	12	66	32	----	----	----	1.69	−1.8	11	6,746	ne.	54	nw.	9	14	12	5	4.0	0.0	0.0
Louisville	525	188	234	29.47	30.04	+.04	77.8	+0.8	102	8	89	57	12	67	30	64	57	57	1.20	−2.2	8	5,298	n.	62	nw.	9	10	19	2	4.4	0.0	0.0
Evansville	431	76	116	29.56	30.02	+.03	78.8	+1.4	105	9	90	57	22	68	28	66	58	55	1.29	−2.1	5	4,323	n.	32	n.	9	10	13	8	5.0	0.0	0.0
Indianapolis	822	194	230	29.16	30.03	+.03	75.4	+1.7	99	9	86	54	12	65	28	63	56	58	2.08	−1.2	11	5,595	ne.	42	nw.	9	8	15	8	5.5	0.0	0.0
Royal Center	736	11	55	29.27	30.05	------	71.0	------	93	3	82	44	12	60	32	----	----	----	2.23	−0.3	12	4,176	ne.	60	w.	9	10	10	11	5.7	0.0	0.0
Terre Haute	575	96	129	29.42	30.03	------	77.2	------	102	8	88	56	11	66	31	65	59	61	1.68	−1.6	9	4,703	n.	33	nw.	9	11	9	11	5.4	0.0	0.0
Cincinnati	627	11	51	29.37	30.04	+.03	75.4	+1.8	101	4	88	58	12	63	35	63	56	60	1.24	−2.2	9	3,396	ne.	22	nw.	9	12	12	7	5.0	0.0	0.0
Columbus	822	216	230	29.17	30.03	+.02	73.0	0.0	98	9	83	54	12	63	31	62	55	60	2.45	−0.8	11	5,089	n.	34	nw.	9	12	10	9	5.1	0.0	0.0
Dayton	899	137	173	29.10	30.03	------	73.6	+0.2	98	4	84	54	12	63	32	63	57	64	4.98	+1.7	12	3,728	ne.	30	nw.	9	11	14	6	5.0	0.0	0.0
Elkins	1,947	59	67	28.05	30.05	+.03	66.6	−2.5	94	4	80	37	12	54	45	59	55	75	1.28	−2.6	9	2,118	nw.	17	w.	10	8	12	11	6.4	0.0	0.0
Parkersburg	637	77	82	29.40	30.05	+.04	73.8	−0.1	102	4	85	49	12	62	40	62	56	62	1.63	−1.9	10	2,581	se.	26	nw.	8	9	12	10	5.9	0.0	0.0
Pittsburgh	842	353	419	29.14	30.03	+.02	71.6	−1.3	99	4	82	50	12	62	33	60	53	59	1.10	−2.1	7	4,286	w.	24	w.	4	9	15	7	5.5	0.0	0.0
Lower Lake Region							70.3	+0.7										65	1.31	−1.7										5.4		
Buffalo	767	247	280	29.18	30.00	+.01	68.7	+0.1	85	8	76	50	11	62	27	63	61	78	0.69	−2.4	6	7,947	sw.	38	sw.	2	10	12	9	5.4	0.0	0.0
Canton	448	10	61	29.51	29.97	------	65.4	−2.4	86	4	76	46	12	54	34	----	----	----	1.24	−2.4	12	4,680	sw.	29	sw.	4	6	16	9	5.7	0.0	0.0
Ithaca	836	5	100	29.12	30.01	------	67.5	−1.1	96	4	80	40	13	55	38	60	56	71	1.49	−1.9	10	4,283	nw.	24	s.	14	7	13	11	6.0	0.0	0.0
Oswego	335	76	91	29.63	29.99	.00	68.3	−0.1	93	4	77	49	13	60	30	61	57	69	1.34	−1.3	12	4,691	s.	20	nw.	10	8	15	8	5.5	0.0	0.0
Rochester	523	86	102	29.46	30.02	+.03	69.8	+0.6	96	8	79	48	12	60	32	60	55	63	2.05	−0.8	10	4,322	sw.	28	sw.	4	6	16	9	5.9	0.0	0.0
Syracuse	596	65	79	29.37	30.00	+.01	70.8	+2.2	96	3	81	48	13	61	30	----	----	----	1.57	−1.3	11	3,655	s.	20	nw.	10	7	16	8	5.4	0.0	0.0
Erie	714	130	166	29.27	30.02	+.01	70.8	+1.2	94	4	79	53	12	63	28	62	56	62	1.16	−2.1	5	6,926	nw.	32	sw.	4	14	10	7	4.4	0.0	0.0
Cleveland	762	267	337	29.22	30.03	+.02	71.1	+1.1	97	4	78	55	23	64	23	62	55	59	1.84	−0.9	7	6,950	n.	32	nw.	24	6	15	10	6.3	0.0	0.0
Sandusky	629	5	67	29.36	30.04	+.03	72.8	+1.0	99	4	82	51	13	64	31	----	----	----	1.16	−2.0	7	4,235	ne.	23	w.	4	6	16	9	5.7	0.0	0.0
Toledo	628	208	243	29.37	30.04	+.04	72.8	+1.5	96	3	82	54	11	64	26	61	55	58	0.86	−2.0	11	6,831	n.	31	w.	4	15	8	8	4.3	0.0	0.0
Fort Wayne	856	100	119	29.13	30.05	------	72.3	+1.2	92	3	82	52	12	62	28	63	58	67	1.43	−1.7	10	4,453	ne.	43	w.	9	6	10	15	6.5	0.0	0.0
Detroit	730	218	258	29.26	30.04	+.03	73.5	+3.2	96	3	82	54	11	65	27	61	55	58	0.90	−1.9	8	5,541	sw.	25	ne.	17	17	8	6	3.7	0.0	0.0
Upper Lake Region							69.5	+3.3										68	0.74	−2.1										4.1		
Alpena	609	13	92	29.38	30.04	+.04	67.6	+3.5	89	2	78	45	12	57	30	60	56	71	1.14	−1.7	8	6,225	nw.	35	nw.	31	15	12	4	3.9	0.0	0.0
Escanaba	612	54	60	29.39	30.04	+.05	67.1	+2.8	89	8	76	44	11	58	26	60	56	71	0.69	−2.5	8	5,597	s.	23	n.	10	18	10	3	3.6	0.0	0.0
Grand Haven	632	54	89	29.35	30.02	+.03	68.5	+1.4	88	3	77	48	12	60	26	61	56	68	0.43	−2.4	5	5,645	w.	29	sw.	3	11	9	11	5.3	0.0	0.0
Grand Rapids	707	70	87	29.29	30.05	+.05	73.0	+3.3	95	3	84	50	12	62	32	60	53	56	0.40	−2.2	6	6,115	ne.	34	sw.	3	11	13	7	5.1	0.0	0.0
Houghton	668	64	99	29.32	30.04	+.07	67.8	+4.1	92	1	78	48	12	58	33	----	----	----	0.94	−1.8	7	5,248	w.	25	w.	9	21	4	6	3.3	0.0	0.0
Lansing	878	6	49	29.11	30.04	------	70.1	+1.6	97	3	83	45	12	57	33	61	55	64	0.18	−2.6	4	2,737	n.	15	w.	2	12	14	5	4.5	0.0	0.0
Ludington	637	60	66	29.35	30.04	------	67.6	+2.3	87	4	76	49	12	60	24	61	57	72	0.98	−1.6	5	5,182	s.	26	s.	3	20	10	1	2.8	0.0	0.0
Marquette	734	77	111	29.24	30.04	+.06	68.1	+4.3	95	2	77	51	11	59	31	61	58	74	1.16	−1.5	6	5,824	w.	25	s.	30	16	10	5	3.8	0.0	0.0
Port Huron	638	70	120	29.34	30.03	+.03	69.6	+1.8	95	2	79	48	11	60	28	62	57	69	0.56	−2.1	6	6,212	ne.	38	nw.	14	10	15	6	5.1	0.0	0.0
Sault Sainte Marie	614	11	52	29.35	30.04	+.05	66.2	+4.1	89	2	76	45	12	56	31	59	56	76	0.40	−2.2	6	4,315	nw.	28	nw.	10	22	7	2	2.8	0.0	0.0
Chicago	673	7	131	29.33	30.05	+.05	73.4	+1.8	98	3	80	56	12	66	26	64	60	70	1.17	−2.0	9	5,279	ne.	30	n.	9	13	10	8	5.0	0.0	0.0
Green Bay	617	109	141	29.37	30.03	+.04	71.2	+3.5	94	4	82	50	18	60	29	62	57	65	0.59	−2.6	5	5,661	n.	23	n.	16	11	12	8	5.1	0.0	0.0
Milwaukee	631	125	221	29.31	30.04	+.04	72.8	+3.6	95	3	80	56	11	65	26	63	58	64	1.46	−1.2	10	6,779	n.	52	sw.	31	14	11	6	4.3	0.0	0.0
Duluth	1,133	5	47	28.84	30.03	+.06	70.2	+7.6	97	1	82	45	12	58	35	60	55	67	0.29	−2.9	4	6,689	ne.	33	sw.	1	19	12	0	2.8	0.0	0.0
North Dakota							71.1	+5.0										59	2.09	−0.3										5.0		
Moorhead	940	50	58	28.99	29.99	+.03	72.2	+6.1	98	1	85	45	10	59	38	60	53	58	0.92	−2.0	8	4,589	s.	27	nw.	29	8	13	10	5.6	0.0	0.0
Bismarck	1,674	8	57	28.22	29.97	+.03	71.3	+4.9	97	6	84	45	10	59	38	60	54	62	1.71	−0.1	9	4,838	e.	35	nw.	6	12	10	9	5.0	0.0	0.0
Devils Lake	1,478	11	44	28.44	29.99	+.05	69.5	+4.7	95	1	83	41	10	56	37	58	52	62	0.62	−1.9	7	4,546	se.	21	n.	31	14	5	12	4.8	0.0	0.0
Ellendale	1,457	10	56	28.45	29.99	------	71.0	------	98	2	85	41	10	57	42	----	----	----	5.01	+1.9	9	7,672	s.	45	se.	21	5	15	11	6.1	0.0	0.0
Grand Forks	833	12	67	----	----	----	71.0	------	98	2	85	41	10	57	40	60	----	----	1.24	------	4	----	se.	29	nw.	31	18	12	1	----	0.0	0.0
Williston	1,878	41	48	28.03	29.96	+.03	71.4	+5.3	98	1	84	43	31	58	42	58	49	53	2.17	+0.7	9	3,858	se.	20	ne.	26	19	5	7	3.7	0.0	0.0
Upper Mississippi Valley							75.8	+3.0										61	1.39	−1.9										5.0		
Minneapolis	918	102	208	29.02	29.99	------	75.2	+5.3	98	3	86	54	10	65	28	----	----	----	0.72	−2.4	7	5,548	s.	30	nw.	1	11	11	9	5.1	0.0	0.0
St. Paul	837	236	261	29.13	30.02	+.05	74.0	+4.6	98	3	85	53	10	63	29	----	----	----	0.48	−2.5	6	5,670	se.	32	w.	1	10	14	7	4.8	0.0	0.0
La Crosse	714	11	48	29.26	30.01	+.03	72.2	+2.2	98	3	85	48	12	59	34	62	58	70	0.90	−2.8	7	1,874	s.	13	sw.	27	12	12	7	4.7	0.0	0.0
Madison	974	70	78	29.01	30.03	+.04	72.5	+2.7	94	3	82	55	12	63	25	62	57	63	1.58	−1.6	9	3,892	s.	15	e.	17	12	15	4	4.6	0.0	0.0
Wausau	1,247	4	62	28.75	30.06	------	70.2	------	94	4	83	46	12	57	35	----	----	----	1.56	−2.0	8	3,041	n.	15	w.	1	11	11	9	5.1	0.0	0.0
Charles City	1,015	10	51	28.98	30.04	+.07	72.4	+3.3	101	3	84	50	11	61	32	63	58	66	1.45	−2.0	6	2,800	se.	25	nw.	5	14	11	6	4.1	0.0	0.0
Davenport	606	71	79	29.38	30.03	+.05	75.6	+2.5	103	3	86	56	22	65	29	64	59	62	2.42	−1.1	10	3,940	ne.	38	nw.	9	10	8	13	5.8	0.0	0.0
Des Moines	861	5	99	29.12	30.01	+.04	75.8	+2.7	105	3	87	53	11	65	31	64	59	61	1.00	−2.5	12	4,601	e.	25	s.	31	6	14	11	6.0	0.0	0.0
Dubuque	700	81	96	29.30	30.03	+.05	74.2	+2.5	103	3	85	53	22	63	31	64	58	64	1.92	−1.3	5	2,778	n.	27	nw.	5	10	13	8	5.0	0.0	0.0
Keokuk	614	64	78	29.37	30.04	+.06	78.0	+3.0	106	3	89	59	21	67	32	65	59	58	2.11	−1.1	9	3,350	ne.	18	sw.	3	8	11	12	5.7	0.0	0.0
Cairo	358	87	93	29.64	30.01	+.02	79.4	+1.6	106	9	90	61	22	69	28	66	60	59	0.76	−2.3	8	4,249	s.	23	n.	10	14	9	8	4.6	0.0	0.0
Peoria	609	11	45	29.39	30.05	+.06	76.1	+3.6	103	3	88	52	23	64	39	64	59	64	1.56	−1.6	6	2,654	ne.	21	n.	9	9	10	12	5.8	0.0	0.0
Springfield, Ill.	636	154	191	29.36	30.02	+.03	77.0	+2.5	102	3	87	57	21	67	28	65	58	58	2.68	−0.5	8	6,083	ne.	43	n.	9	9	10	12	5.8	0.0	0.0
Hannibal	534	74	109	29.47	30.04	+.06	78.0	+3.0	104	9	89	54	22	66	35	----	----	----	1.45	−1.9	11	4,053	sw.	21	sw.	3	13	6	12	5.2	0.0	0.0
St. Louis	568	265	303	29.42	30.01	+.02	80.4	+3.1	105	4	90	59	22	71	25	65	57	51	0.28	−2.7	6	5,800	s.	24	sw.	3	16	8	7	4.5	0.0	0.0
Missouri Valley							77.2	+3.3										62	2.91	−0.3										5.0		
Columbia, Mo.	784	6	84	29.20	30.01	+.04	78.4	+2.8	107	9	90	58	24	67	35	----	----	----	2.18	−1.4	7	3,916	sw.	17	n.	18	7	16	8	5.5	0.0	0.0
Kansas City	963	161	181	28.98	29.98	+.01	80.2	+3.6	107	3	90	56	12	71	28	66	58	54	3.48	−0.6	8	5,609	e.	21	n.	18	15	12	4	4.1	0.0	0.0
St. Joseph	967	11	49	28.98	29.98	------	78.8	------	107	3	90	59	25	68	29	66	61	61	3.29	−0.2	11	4,218	se.	30	nw.	16	18	8	5	3.8	0.0	0.0
Springfield, Mo.	1,324	98	104	28.65	30.03	+.06	78.9	+3.2	101	3	89	60	12	69	26	65	57	53	3.02	−1.1	6	5,224	se.	29	w.	16	27	4	0	1.4	0.0	0.0
Iola	984	11	50	28.96	29.98	+.02	81.0	+3.9	108	4	94	58	23	68	40	----	----	----	1.60	−1.9	9	2,938	s.	24	se.	4	13	13	5	4.4	0.0	0.0
Topeka	987	92	107	----	----	----	80.0	+3.8	110	3	91	58	12	69	32	----	----	----	2.88	−1.2	9	5,089	sw.	31	se.	4	11	16	4	4.6	0.0	0.0
Lincoln	1,189	11	81	28.74	29.97	+.02	77.2	+2.8	108	3	88	57	12	67	32	67	63	70	3.75	+0.2	15	4,835	e.	29	nw.	30	3	18	10	6.4	0.0	0.0
Omaha	1,105	115	122	28.84	29.99	+.03	76.7	+2.3	111	3	87	60	11	67	31	66	61	67	6.28	+3.2	14	3,306	e.	35	nw.	30	6	19	6	5.3	0.0	0.0
Valentine	2,598	47	54	27.32	29.98	+.04	73.3	+1.6	103	2	85	50	31	62	36	63	58	68	2.31	+0.1	13	5,124	w.	22	sw.	1	4	17	10	5.9	0.0	0.0
Sioux City	1,135	94	164	28.81	29.99	+.04	75.6	+3.6	105	3	85	56	25	66	29	65	60	64	0.89	−2.2	8	5,929	s.	27	s.	31	4	14	13	6.7	0.0	0.0
Huron	1,306	59	74	28.62	29.98	+.03	74.6	+5.2	104	1	86	53	31	63	39	63	58	64	3.58	+1.1	10	5,495	se.	36	sw.	1	13	10	8	5.0	0.0	0.0
Pierre	1,572	70	75	28.31	29.94	.00	75.4	+2.6	107	2	87	50	31	64	38	63	56	59	2.61	+0.5	9	5,371	e.	35	n.	6	8	15	8	5.5	0.0	0.0
Yankton	1,233	49	57	28.69	29.98	+.03	75.7	+3.7	108	3	86	56	21	65	31	----	----	----	1.96	−1.0	11	3,901	se.	22	nw.	31	6	16	10	6.3	0.0	0.0

TABLE 1.—*Climatological data for Weather Bureau station, August, 1930*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with .01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0–10	In.	In.
Northern Slope							69.7	+3.4										58	2.03	+0.8										5.0		
Billings	3,140	5		27.38	29.96	+0.05	72.2		99	25	88	43	31	56	43				1.35		10		nw.				5	14	12		0.0	0.0
Havre	2,505	11	44	27.38	29.96	+0.05	72.2	+6.8	100	24	88	38	31	57	41	56	44	45	0.34	−0.9	7	3,533	e.	27	n.	30	15	13	3	3.6	0.0	0.0
Helena	4,124	89	113	25.85	29.96	+.02	69.4	+4.4	93	8	83	39	31	56	34	54	44	48	0.54	−0.2	8	4,863	sw.	31	sw.	23	6	18	7	5.6	0.0	0.0
Kalispell	2,973	48	56	26.95	29.94	+.01	68.0	+5.2	98	8	84	42	31	52	43	53	41	46	0.23	−0.6	3	3,651	nw.	20	ne.	30	14	14	3	4.3	0.0	0.0
Miles City	2,371	48	55	27.49	29.98	+.05	75.6	+4.1	100	6	88	42	31	63	37	60	51	51	0.93	−0.2	8	3,447	s.	24	nw.	22	14	13	4	4.6	0.0	0.0
Rapid City	3,259	50	58	26.68	30.02	+.09	72.5	+3.0	97	1	83	45	31	62	35	60	53	57	0.96	−0.7	6	4,304	w.	25	ne.	31	5	16	10	6.2	0.0	0.0
Cheyenne	6,088	84	101	24.15	30.00	+.08	66.2	+0.6	87	20	77	48	30	55	33	56	51	66	6.73	+5.2	16	5,610	w.	38	sw.	31	6	19	6	5.6	0.0	0.0
Lander	5,372	60	68	24.76	30.00	+.08	67.0	+1.5	88	25	80	43	31	54	37	56	50	64	4.35	+3.8	13	2,839	sw.	30	w.	31	15	12	4	4.6	0.0	0.0
Sheridan	3,790	10	47	26.16	29.99	------	70.2	------	94	25	85	38	31	56	42	58	51	60	0.36	−0.6	9	2,753	se.	25	sw.	22	7	15	9	5.7	0.0	0.0
Yellowstone Park	6,241	11	48	------	------	------	61.0	+0.1	82	24	74	30	31	48	39	------	------	69	4.13	+3.1	18	3,757	sw.	32	sw.	1	4	15	12	------	0.0	0.0
North Platte	2,821	11	51	27.10	29.97	+.03	75.4	+4.6	102	2	87	57	28	64	35	65	62	72	1.72	−0.7	17	3,617	se.	21	nw.	4	12	8	11	5.0	0.0	0.0
Middle Slope							78.3	+2.3																						3.8		
Denver	5,292	106	113	24.85	30.00	+.08	71.6	+0.9	91	3	82	55	17	61	30	58	51	58	2.02	+0.6	12	4,059	s.	26	nw.	17	8	18	5	5.2	0.0	0.0
Pueblo	4,685	80	86	25.35	29.93	+.02	73.7	+1.0	96	2	87	53	30	60	37	59	53	59	3.03	+1.2	12	3,687	nw.	28	w.	14	13	13	5	4.4	0.0	0.0
Concordia	1,392	50	58	28.54	29.98	+.03	79.6	+3.1	108	3	91	60	12	68	33	67	62	62	1.85	−1.1	12	4,410	s.	30	s.	16	12	17	2	4.5	0.0	0.0
Dodge City	2,509	11	51	27.43	29.96	+.03	80.4	+2.7	105	3	94	60	26	67	33	65	58	56	0.55	−2.1	7	5,558	se.	30	e.	20	24	5	2	2.0	0.0	0.0
Wichita	1,358	139	158	28.56	29.95	.00	80.7	+2.4	105	3	92	61	22	70	31	67	61	57	2.96	−0.2	9	7,083	s.	34	nw.	16	19	10	2	3.4	0.0	0.0
Broken Arrow	765	11	56	29.18	30.00	------	82.2	------	105	3	95	60	25	70	33	------	------	------	1.34	−2.5	6	5,865	sw.	31	e.	4	15	13	3	4.0	0.0	0.0
Oklahoma City	1,214	10	47	28.71	29.95	+.01	83.6	+3.9	106	3	96	63	23	71	30	69	62	57	3.12	+0.2	5	4,952	s.	34	nw.	20	22	6	3	3.0	0.0	0.0
Southern Slope							82.7	+3.0										50	1.05	−1.2										3.0		
Abilene	1,738	10	52	28.18	29.94	+.02	85.4	+3.4	105	19	98	64	29	73	32	67	58	48	0.59	−1.6	9	5,298	s.	26	sw.	15	13	15	3	4.1	0.0	0.0
Amarillo	3,676	10	49	26.32	29.96	+.04	79.8	+4.1	100	3	93	60	26	67	34	63	54	51	1.61	−1.5	8	5,558	s.	22	se.	22	21	8	2	2.9	0.0	0.0
Del Rio	944	64	71	28.94	29.90	.00	86.6	+2.4	101	20	98	69	28	76	30	69	60	49	0.08	−1.6	2	5,995	se.	23	se.	8	25	6	0	2.1	0.0	0.0
Roswell	3,566	75	85	26.40	29.93	+.05	78.9	+2.3	102	20	93	57	29	65	36	62	53	52	1.92	−0.2	6	4,203	s.	32	se.	6	22	8	1	2.8	0.0	0.0
Southern Plateau							78.0	+0.6										50	0.84	−0.3										2.8		
El Paso	3,778	152	175	26.21	29.88	+.04	81.6	+2.4	100	19	93	64	10	70	29	62	51	41	1.29	−0.4	5	4,460	e.	32	nw.	25	22	7	2	2.5	0.0	0.0
Santa Fe	7,013	38	53	23.40	29.93	+.04	67.6	+0.2	87	21	80	50	15	56	31	54	46	56	1.99	−0.3	13	3,042	e.	20	nw.	29	19	7	5	4.0	0.0	0.0
Flagstaff	6,907	10	59	23.50	29.93	+.09	63.2	+0.4	86	27	77	42	18	49	39	52	------	66	1.90	------	12	4,340	nw.	31	nw.	13	7	17	7	------	0.0	0.0
Phoenix	1,108	10	107	28.69	29.81	+.02	89.6	+1.1	111	27	103	70	9	77	37	69	58	41	0.86	−0.1	6	3,121	e.	24	n.	10	18	10	3	2.9	0.0	0.0
Yuma	141	9	54	29.67	29.81	+.05	89.6	−0.8	113	27	104	67	19	75	41	72	62	47	0.04	−0.5	2	2,941	sw.	30	se.	1	24	6	1	1.9	0.0	0.0
Independence	3,957	6	27	25.98	29.93	+.12	76.4	+0.3	96	22	92	54	19	61	41	55	------	------	T.	−0.1	0	------	nw.	------	------	------	------	17	9	5	------	0.0	0.0
Middle Plateau							71.7	+0.6										46	1.26	+0.5										3.9		
Reno	4,532	74	81	25.51	29.93	+.09	69.0	+2.0	94	7	85	42	20	52	43	52	40	43	0.48	+0.3	4	4,201	w.	31	w.	10	22	6	3	2.8	0.0	0.0
Tonopah	6,090	12	20	------	------	------	71.0	------	87	21	82	55	2	60	27	53	39	37	1.29	------	8	------	se.	------	------	------	------	------	------	------	------	------	------
Winnemucca	4,344	18	56	25.65	29.96	+.08	70.3	+1.0	94	6	88	44	22	53	48	53	41	44	0.38	+0.2	8	3,338	sw.	29	w.	2	17	10	4	3.7	0.0	0.0
Modena	5,473	10	43	24.69	29.92	+.06	68.4	−0.8	89	29	83	48	19	54	40	54	44	55	2.72	+1.4	11	6,216	sw.	38	w.	3	10	12	9	4.9	0.0	0.0
Salt Lake City	4,360	163	203	25.66	29.95	+.04	74.8	+0.3	92	21	85	60	15	65	28	60	52	51	1.87	+1.0	11	4,785	s.	32	n.	27	11	15	5	4.5	0.0	0.0
Grand Junction	4,602	60	68	25.44	29.96	+.06	75.9	+0.5	95	6	88	50	15	63	32	59	48	46	0.86	−0.3	12	3,888	se.	24	sw.	12	20	8	3	3.5	0.0	0.0
Northern Plateau							73.4	+3.5										43	1.07	+0.6										4.0		
Baker	3,471	48	53	26.48	30.00	+.05	68.0	+3.4	96	7	84	42	31	52	42	53	40	45	1.16	+0.7	5	3,473	se.	26	w.	15	13	10	8	4.5	0.0	0.0
Boise	2,739	78	86	27.14	29.93	.00	74.8	+3.0	98	6	88	48	31	61	38	58	47	43	0.78	+0.6	3	2,943	nw.	16	se.	3	12	13	6	4.6	0.0	0.0
Lewiston	757	40	48	29.14	29.93	−.02	77.4	+4.6	106	7	93	51	27	61	42	------	------	------	0.19	−0.4	4	2,086	e.	26	s.	15	19	9	3	3.2	0.0	0.0
Pocatello	4,477	60	68	25.52	29.94	+.02	71.2	+1.6	92	7	83	52	28	59	37	57	49	54	3.59	+2.9	11	4,502	se.	29	sw.	5	8	17	6	5.1	0.0	0.0
Spokane	1,929	101	110	27.94	29.94	−.01	72.8	+4.7	104	8	88	47	27	58	42	55	41	38	0.57	0.0	3	3,023	s.	32	nw.	15	18	12	1	2.8	0.0	0.0
Walla Walla	991	57	65	28.89	29.94	−.02	76.4	+3.7	101	7	90	53	21	63	37	58	44	36	0.14	−0.4	5	2,623	s.	16	se.	19	16	12	3	3.5	0.0	0.0
North Pacific Coast Region							65.9	+2.6										65	0.20	−0.5										3.8		
North Head	211	11	56	29.86	30.08	+.05	60.4	+2.8	68	25	64	53	11	57	11	58	57	88	0.19	−0.9	5	8,709	n.	35	s.	15	7	13	11	5.5	0.0	0.0
Port Angeles	29	8	53	------	30.08	------	59.6	------	80	14	68	45	26	51	29	------	------	------	0.49	−0.2	1	3,753	sw.	18	w.	9	14	11	6	------	0.0	0.0
Seattle	125	215	250	29.90	30.03	+.03	65.3	+2.2	86	11	75	50	26	56	28	58	52	66	0.08	−0.6	3	3,796	nw.	26	n.	8	17	8	6	3.7	0.0	0.0
Tacoma	194	172	201	29.85	30.05	+.03	65.2	+2.6	86	11	75	49	21	55	28	------	------	------	0.10	−0.6	3	3,962	n.	21	w.	24	16	11	4	3.6	0.0	0.0
Tatoosh Island	86	9	53	29.97	30.06	+.06	57.0	+1.7	67	23	61	49	12	53	12	56	55	93	0.90	−1.1	6	5,278	sw.	37	s.	15	9	12	10	6.1	0.0	0.0
Yakima	1,076	58	67	28.82	29.95	------	75.1	+5.6	102	11	90	54	21	61	36	57	43	37	T.	−0.2	0	3,937	nw.	23	se.	18	20	8	3	2.5	0.0	0.0
Medford	1,329	29	58	28.58	29.96	------	71.8	------	101	12	89	48	21	55	42	57	46	49	T.	−0.2	0	------	w.	28	nw.	11	23	8	0	2.0	0.0	0.0
Portland, Oreg	153	68	106	29.87	30.02	+.01	69.8	+3.1	96	11	81	51	21	59	34	60	54	61	0.06	−0.6	3	3,154	nw.	13	sw.	15	14	10	7	4.0	0.0	0.0
Roseburg	510	75	99	29.48	30.02	+.02	68.3	+0.3	97	11	82	47	21	54	38	58	50	59	T.	−0.3	0	2,725	n.	17	nw.	14	20	7	4	2.7	0.0	0.0
Middle Pacific Coast Region							67.7	+0.8										66	T.	0.0										2.8		
Eureka	62	73	89	30.02	30.09	+.09	59.8	+3.8	69	15	64	50	22	55	18	57	55	85	T.	−0.2	0	3,165	nw.	24	n.	31	7	12	12	5.9	0.0	0.0
Red Bluff	330	5	58	29.55	29.89	+.03	78.3	−1.4	104	13	94	56	3	62	38	60	45	37	0.00	0.0	0	3,266	s.	14	se.	14	27	3	1	1.3	0.0	0.0
Sacramento	69	106	117	29.84	29.91	+.06	72.8	−0.1	98	11	89	51	4	56	42	61	53	58	T.	0.0	0	5,648	s.	18	s.	2	30	1	0	0.6	0.0	0.0
San Francisco	155	208	243	29.81	29.98	+.06	61.5	+2.4	77	20	68	52	6	55	22	57	54	82	0.00	0.0	0	6,017	sw.	26	w.	2	13	14	4	3.9	0.0	0.0
San Jose	141	12	110	29.86	30.01	------	66.0	−0.7	87	21	78	48	20	54	38	------	------	------	0.01	0.0	1	3,998	nw.	17	nw.	5	26	4	1	2.1	0.0	0.0
South Pacific Coast Region							74.3	+0.8										62	T.	0.0										2.9		
Fresno	327	89	98	29.55	29.90	+.08	78.8	−1.9	102	1	95	57	17	63	38	60	46	37	T.	0.0	0	5,541	nw.	20	nw.	14	26	4	1	1.3	0.0	0.0
Los Angeles	338	159	191	29.58	29.94	+.06	73.8	+2.7	93	1	83	62	19	65	26	64	59	68	0.00	0.0	0	2,818	sw.	12	w.	26	20	10	1	2.7	0.0	0.0
San Diego	87	62	70	29.84	29.93	+.04	70.3	+1.6	85	1	75	61	20	65	18	65	62	80	T.	0.0	0	3,803	w.	17	nw.	26	13	12	6	4.6	0.0	0.0
West Indies																																
San Juan, P. R.	82	9	54	29.91	30.00	------	81.1	+0.6	93	26	86	72	12	76	16	------	------	------	3.51	−2.5	15	7,983	e.	44	e.	12	12	18	1	4.4	0.0	0.0
Panama Canal																																
Balboa Heights	118	6	97	------	[2]29.83	.00	81.0	−0.2	93	6	88	71	3	74	18	------	------	[1]84	4.34	−3.7	13	4,887	nw.	28	ne.	3	0	18	16	7.5	0.0	0.0
Cristobal	36	7	97	------	[2]29.84	−.01	82.0	+1.8	89	8	87	74	3	78	13	76	75	[1]83	14.35	−1.0	21	7,142	n.	28	nw.	29	0	1	22	8.1	0.0	0.0
Alaska																																
Fairbanks	455	11	44	[2]29.40	[2]29.91	------	54.0	------	78	8	63	34	16	45	32	51	48	79	6.88	------	20	3,147	sw.	------	------	------	0	8	23	8.3	0.0	0.0
Juneau	80	11	50	[2]29.96	[2]30.05	------	55.6	------	73	6	62	44	30	50	24	54	52	88	9.46	------	22	5,237	s.	26	e.	12	5	6	20	7.8	0.0	0.0
Hawaiian Islands																																
Honolulu	38	86	100	[2]29.93	[2]29.98	------	79.1	+0.7	85	19	83	71	31	75	11	72	69	73	0.93	−0.4	16	6,959	e.	25	e.	11	13	5	13	5.6	0.0	0.0

[1] Observations taken hourly.

[2] Pressure not reduced to mean of 24 hours.

TABLE 2.—*Data furnished by the Canadian Meteorological Service, August, 1930*

Stations	Altitude above mean sea level, Jan. 1, 1919	Pressure			Temperature of the air						Precipitation		
		Station reduced to mean of 24 hours	Sea level reduced to mean of 24 hours	Departure from normal	Mean max.+mean min.÷2	Departure from normal	Mean maximum	Mean minimum	Highest	Lowest	Total	Departure from normal	Total snowfall
	Feet	*Inches*	*Inches*	*Inches*	*° F.*	*° F.*	*° F.*	*° F.*	*° F.*	*° F.*	*Inches*	*Inches*	*Inches*
Cape Race, N. F.	99				57.0		64.6	49.5	75	38	4.46		0.0
Sydney, C. B. I.	48												
Halifax, N. S.	88	29.91	30.01	+0.05	64.8	+1.2	74.5	55.0	85	46	2.82	−1.53	0.0
Yarmouth, N. S.	65												
Charlottetown, P. E. I.	38	29.90	29.94	.00	66.0	+1.7	73.0	59.0	83	53	2.59	−1.15	0.0
Chatham, N. B.	28	29.87	29.90	−.03	62.7	−0.5	73.5	51.9	83	42	6.42	+2.38	0.0
Father Point, Que.	20												
Quebec, Que.	296	29.66	29.98	+.05	63.6	+0.5	71.0	56.2	79	47	4.13	+0.30	0.0
Doucet, Que.	1,236				57.5		69.8	45.2	80	36	2.96		0.0
Montreal, Que.	187	29.76	29.96	+.01	66.8	+0.4	74.9	58.8	85	50	1.52	−2.05	0.0
Ottawa, Ont.	236	29.71	29.97	+.01	67.0	+2.2	78.3	55.7	87	42	1.17	−1.86	0.0
Kingston, Ont.	285	29.69	29.99	+.01	66.6	−0.4	73.9	59.3	82	46	1.55	−0.83	0.0
Toronto, Ont.	379	29.60	29.99	.00	69.1	+3.1	79.6	58.6	95	46	0.89	−1.87	0.0
Cochrane, Ont.	930				62.4		72.9	51.9	86	37	2.14		0.0
White River, Ont.	1,244	28.70	29.99	+.03	59.4	+3.0	76.6	42.2	92	29	0.94	−2.36	0.0
London, Ont.	808				68.9		83.0	54.9	96	40	1.40		0.0
Southampton, Ont.	656	29.31	30.02	+.03	65.1	+1.3	75.2	54.9	84	42	1.34	−0.91	0.0
Parry Sound, Ont.	688	29.32	30.00	+.02	66.7	+3.2	76.4	57.0	83	45	2.28	−0.44	0.0
Port Arthur, Ont.	644	29.33	30.02	+.06	65.4	+5.9	77.1	53.8	89	45	2.08	−0.67	0.0
Winnipeg, Man.	760												
Minnedosa, Man.	1,690	28.22	30.00	+.06	65.8	+6.4	80.2	51.5	93	37	0.92	−1.18	0.0
Le Pas, Man.	860				64.9		77.1	52.8	92	40	0.94		0.0
Qu'Appelle, Sask.	2,115	27.78	30.00	+.07	65.7	+4.2	78.7	52.7	95	40	0.95	−0.69	0.0
Moose Jaw, Sask.	1,759				68.8		83.6	53.9	97	40	1.08		0.0
Swift Current, Sask.	2,392	27.43	29.89	−.04	68.1	+4.1	84.2	52.0	95	33	1.53	−0.38	0.0
Medicine Hat, Alb.	2,144												
Calgary, Alb.	3,428												
Banff, Alb.	4,521												
Prince Albert, Sask.	1,450	28.45	30.00	+.08	64.8	+5.9	77.4	52.2	96	36	0.91	−1.24	0.0
Battleford, Sask.	1,592	28.25	29.96	+.05	65.2	+2.6	78.7	51.6	95	34	0.22	−2.14	0.0
Edmonton, Alb.	2,150	27.68	29.92	.00	62.8	+4.0	75.7	50.0	88	33	1.44	−0.69	0.0
Kamloops, B. C.	1,262												
Victoria, B. C.	230	29.78	30.03	+.02	60.9	+2.2	68.4	53.5	78	51	0.14	−0.46	0.0
Barkerville, B. C.	4,180												
Estevan Point, B. C.	20												
Prince Rupert, B. C.	170												
Hamilton, Ber.	151	29.97	30.13	+.03	80.7	+1.1	86.5	74.9	90	72	3.84	−2.24	0.0

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Cape Race, N. F.	99				59.4		67.3	51.6	76	46	3.90		0.0
Sydney, C. B. I.	48	29.82	29.87	−0.06	67.3	+5.0	76.7	57.8	85	50	3.42	−0.23	0.0
Halifax, N. S.	88	29.77	29.87	−.09	65.1	+1.7	74.9	55.3	84	49	5.56	+1.51	0.0
Yarmouth, N. S.	65	29.76	29.83	−.12	61.9	+2 4	69.2	54.6	76	48	6.55	+3.08	0.0
Charlottetown, P. E. I.	38	29.74	29.78	−.12	68.1	+4.0	75.2	61.0	82	54	2.42	−1.07	0.0
Chatham, N. B.	28	29.71	29.74	−.14	65.6	+0.6	75.9	55.4	82	45	5.78	+1.59	0.0
Quebec, Que.	296	29.53	29.84	−.07	66.0	+0.5	74.8	57.2	83	47	4.71	+0.45	0.0
Doucet, Que.	1,236				57.4		69.8	44.9	85	30	4.76		0.0
Montreal, Que.	187	29.64	29.84	−.09	69.4	+0.9	77.3	61.6	90	54	5.56	+1.27	0.0
Ottawa, Ont.	236	29.62	29.88	−.06	68.0	−1.5	78.1	57.9	92	44	4.90	+1 43	0.0
Kingston, Ont.	285	29.59	29.89	−.08	67.2	−1.0	74.2	60.2	82	50	5.02	+2.13	0.0
Toronto, Ont.	379	29.52	29.91	−.06	70.1	+2.1	80.9	59.2	92	50	3.10	+0.18	0.0
Cochrane, Ont.	930				61.0		72.0	50.0	88	36	1.74		0.0
White River, Ont.	1,244	28.60	29.89	−.05	58.6	−0.9	73.1	44.1	94	29	1.70	−1.10	0.0
London, Ont.	808				70.2		83.5	56.8	96	40	0.72		0.0
Southampton, Ont.	656	29.24	29.95	−.02	64.1	−0.6	73.2	55.0	86	43	2.79	+0.81	0.0
Parry Sound, Ont.	688	29.25	29.93	−.03	66.0	0.0	75.5	56.5	88	46	2.15	−0.47	0.0
Port Arthur, Ont.	644	29 25	29.96	+ 02	64.3	+2.3	74.5	54.1	87	46	3.60	+0.12	0.0
Winnipeg, Man.	760	29.12	29.93	.00	70.8	+4.8	81.9	59.7	94	51	5.22	+2.14	0.0
Minnedosa, Man.	1,690	28.14	29.91	−.02	66.6	+4.4	78.9	54.3	89	42	2.34	−0.26	0.0
Le Pas, Man.	860				65.5		77.2	53.9	88	39	3.77		0.0
Qu'Appelle, Sask.	2,115	27.71	29.92	.00	65.6	+2.1	78.2	53.0	98	42	0.89	−1.59	0.0
Moose Jaw, Sask.	1,759				69.7		85.0	54.4	100	43	1.20		0.0
Swift Current, Sask.	2,392	27 42	29.88	−.03	68.3	+1.8	83.3	53.4	97	43	0.57	−1.87	0.0
Prince Albert, Sask.	1,450	28.40	29.95	+.04	65.8	+3.9	77.6	54.0	89	47	1.78	−0.27	0.0
Battleford, Sask.	1,592	28.21	29.92	+.02	66.2	+1.5	79.3	53.1	92	45	2.78	+0.44	0.0
Edmonton, Alb.	2,150	27.64	29.87	−.03	63.5	+2.9	76.7	50.3	93	41	1.88	−1.15	0.0
Kamloops, B. C.	1,262	28.70	29.96	+.02	70.6	+2.1	83.2	58 0	99	45	0.51	−1.10	0.0
Victoria, B. C.	230	29.83	30.08	+.03	59.1	−0.9	67.0	51.3	87	48	0.03	−0.37	0.0
Estevan Point, B. C.	20				54.9		61.2	48.6	70	40	0.40		0.0
Prince Rupert, B. C.	170				56.1		63.0	49.3	74	44	5.46		0.0
Hamilton, Ber.	151	30.04	30.20	+.06	78.6	−0.1	84.1	73.1	87	68	2.34	−2.10	0.0

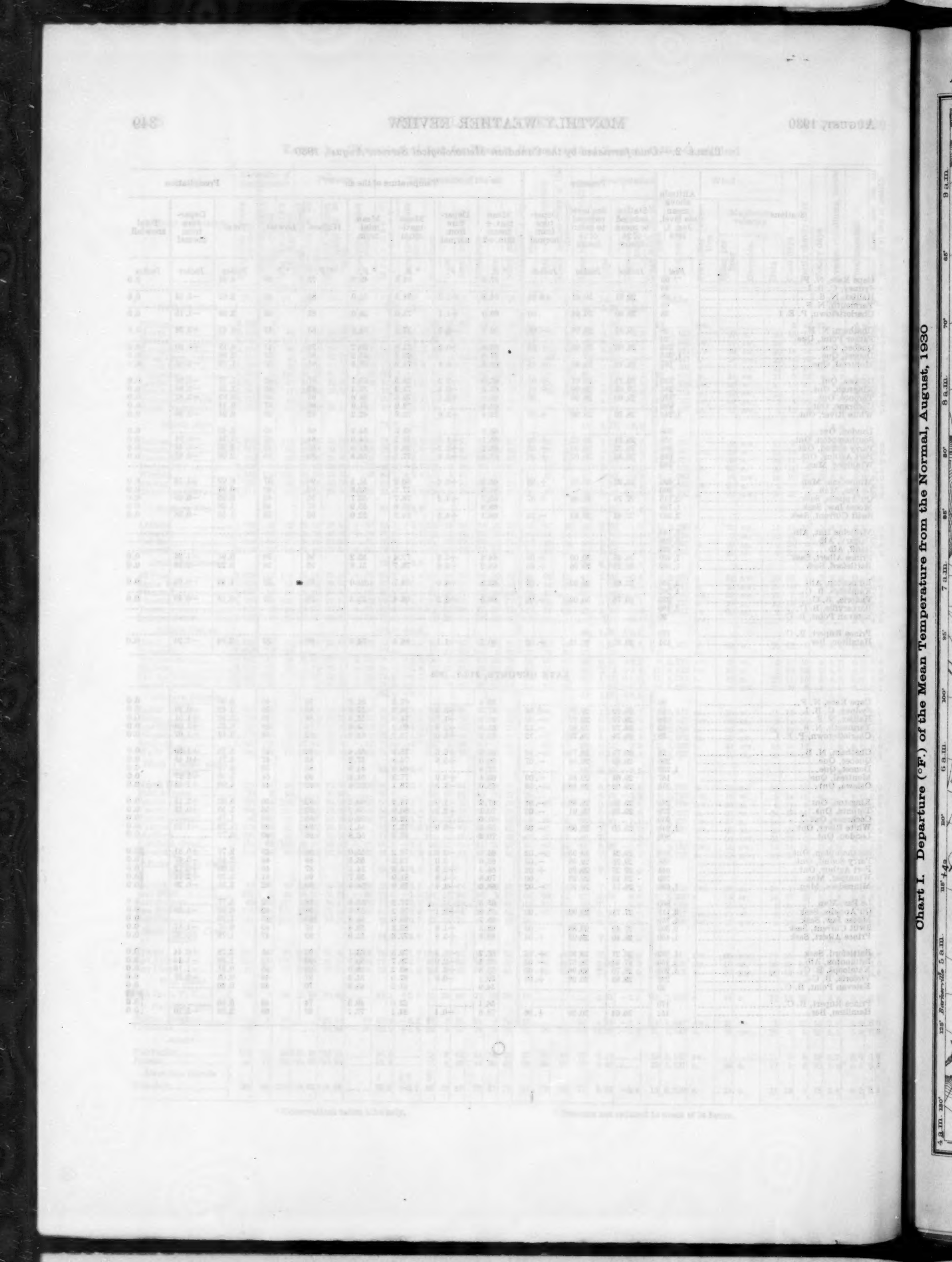


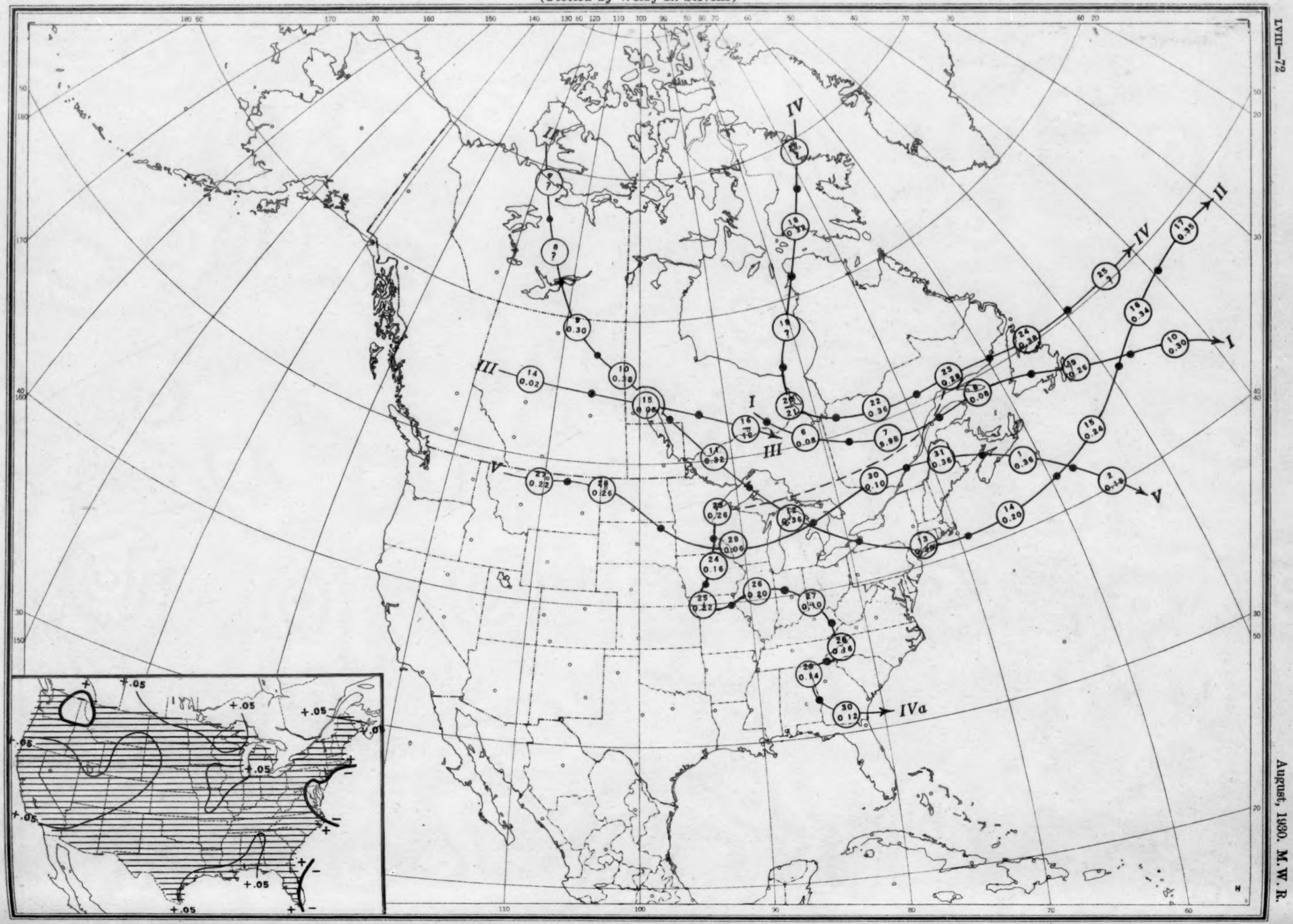
Chart I. Departure (°F.) of the Mean Temperature from the Normal, August, 1930

Chart I. Departure (°F.) of the Mean Temperature from the Normal, August, 1930

Shaded portions show excess (+).
Unshaded portions show deficiency (—).
Lines show amount of excess or deficiency.
Statute Miles
Kilometers

Chart II. Tracks of Centers of Anticyclones, August, 1930. (Inset) **Departure of Monthly Mean Pressure from Normal**

(Plotted by Welby R. Stevens)



Circle indicates position of anticyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 8 p. m. (75th meridian time).

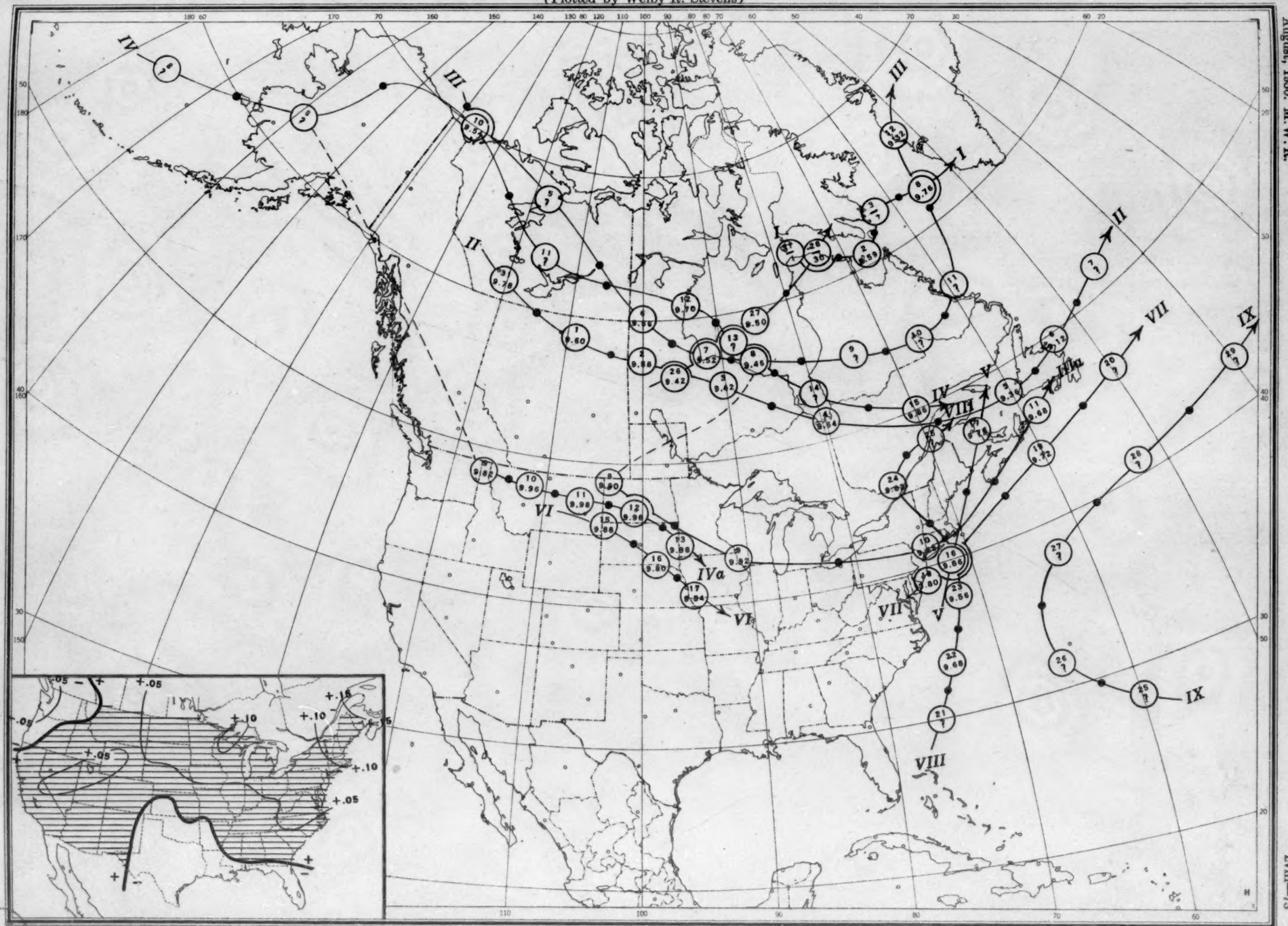
Chart III. Tracks of Centers of Cyclones, August, 1930. (Inset) **Change in Mean Pressure from Preceding Month**

(Plotted by Welby R. Stevens)

Circle indicates position of anticyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 8 p. m. (75th meridian time).

Chart III. Tracks of Centers of Cyclones, August, 1930. (Inset) Change in Mean Pressure from Preceding Month

(Plotted by Welby R. Stevens)



U. S. WEATHER BUREAU
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Circle indicates position of cyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of cyclone at 8 p. m. (75th meridian time).

Chart IV. Percentage of Clear Sky between Sunrise and Sunset, August, 1930

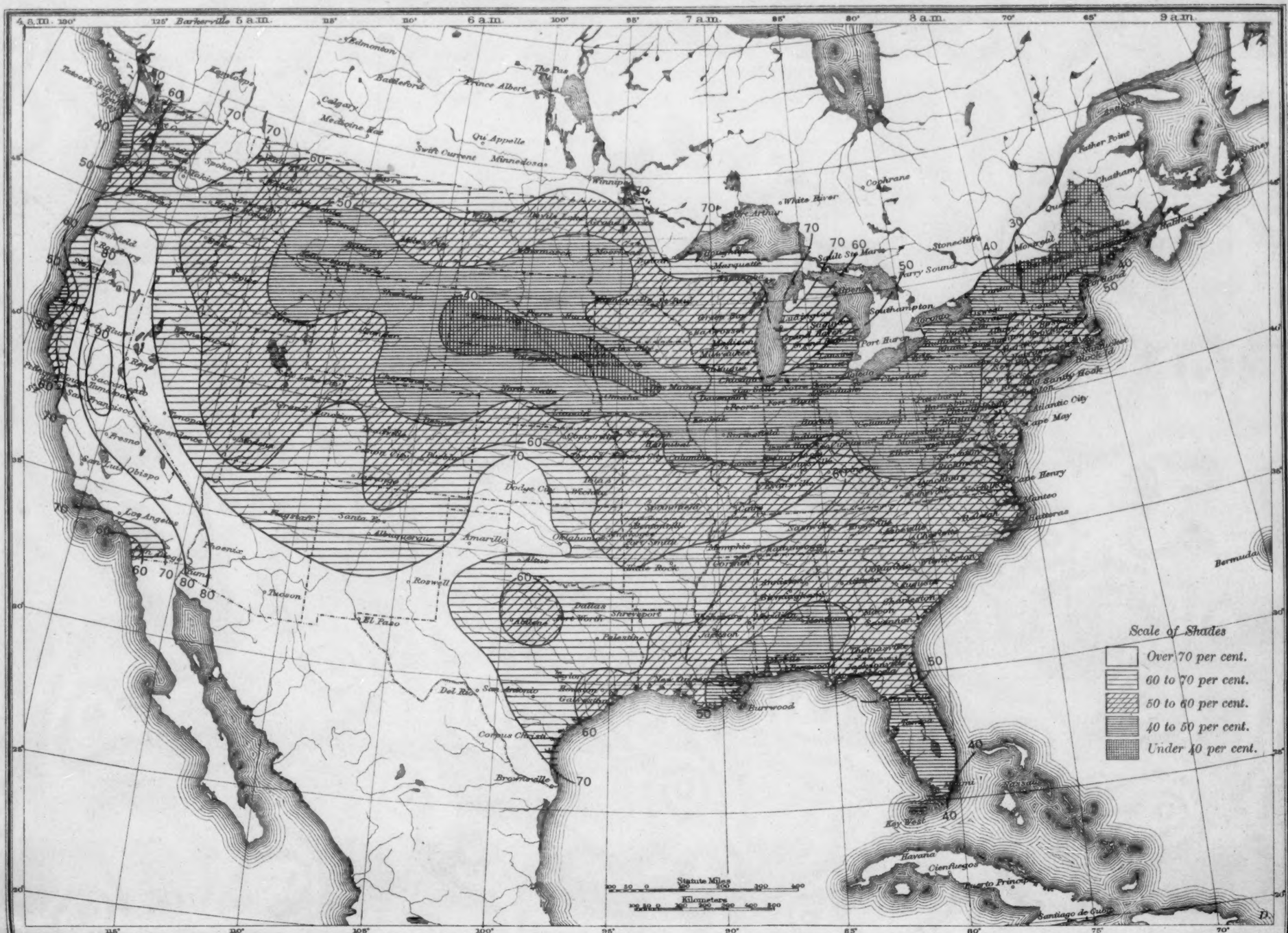


Chart V. Total Precipitation, Inches, August, 1930. (Inset) Departure of Precipitation from Normal

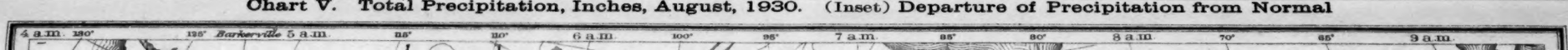


Chart V. Total Precipitation, Inches, August, 1930. (Inset) Departure of Precipitation from Normal

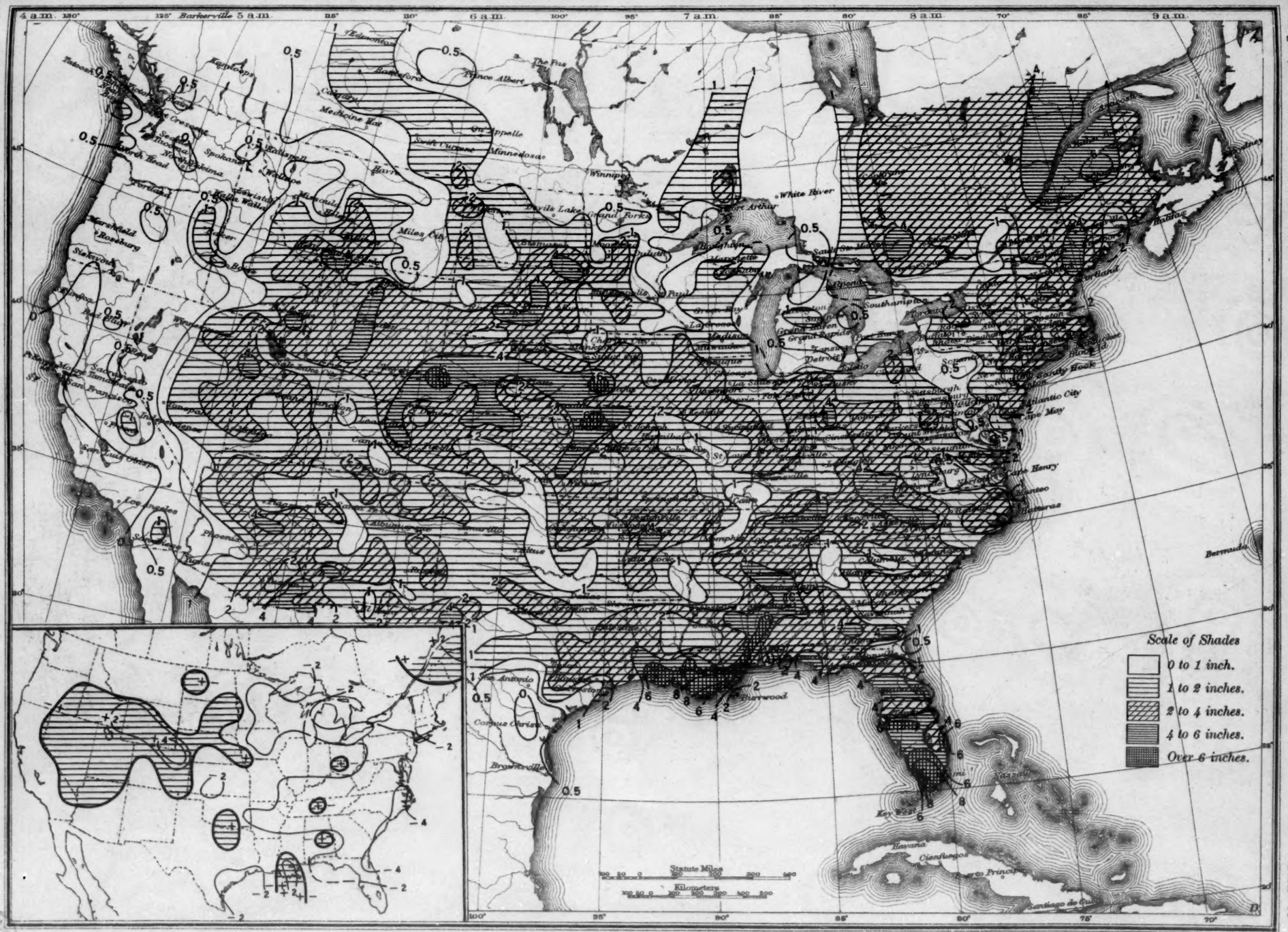


Chart VI. Isobars at Sea level and Isotherms at Surface; Prevailing Winds, August, 1930

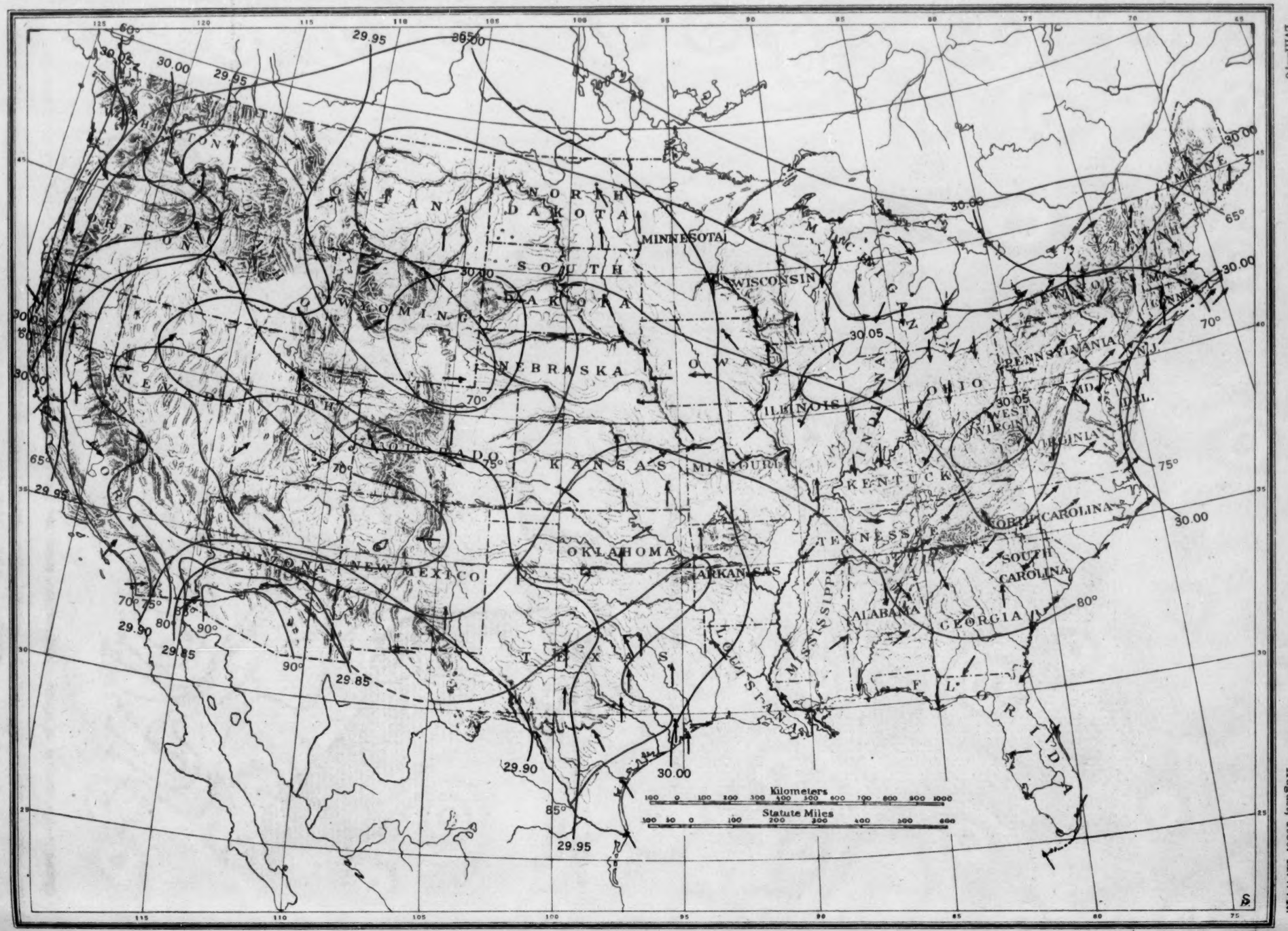


Chart VIII. Weather Map of North Atlantic Ocean, August 25, 1930

(Plotted by F. A. Young)

Chart VIII. Weather Map of North Atlantic Ocean, August 25, 1930

(Plotted by F. A. Young)

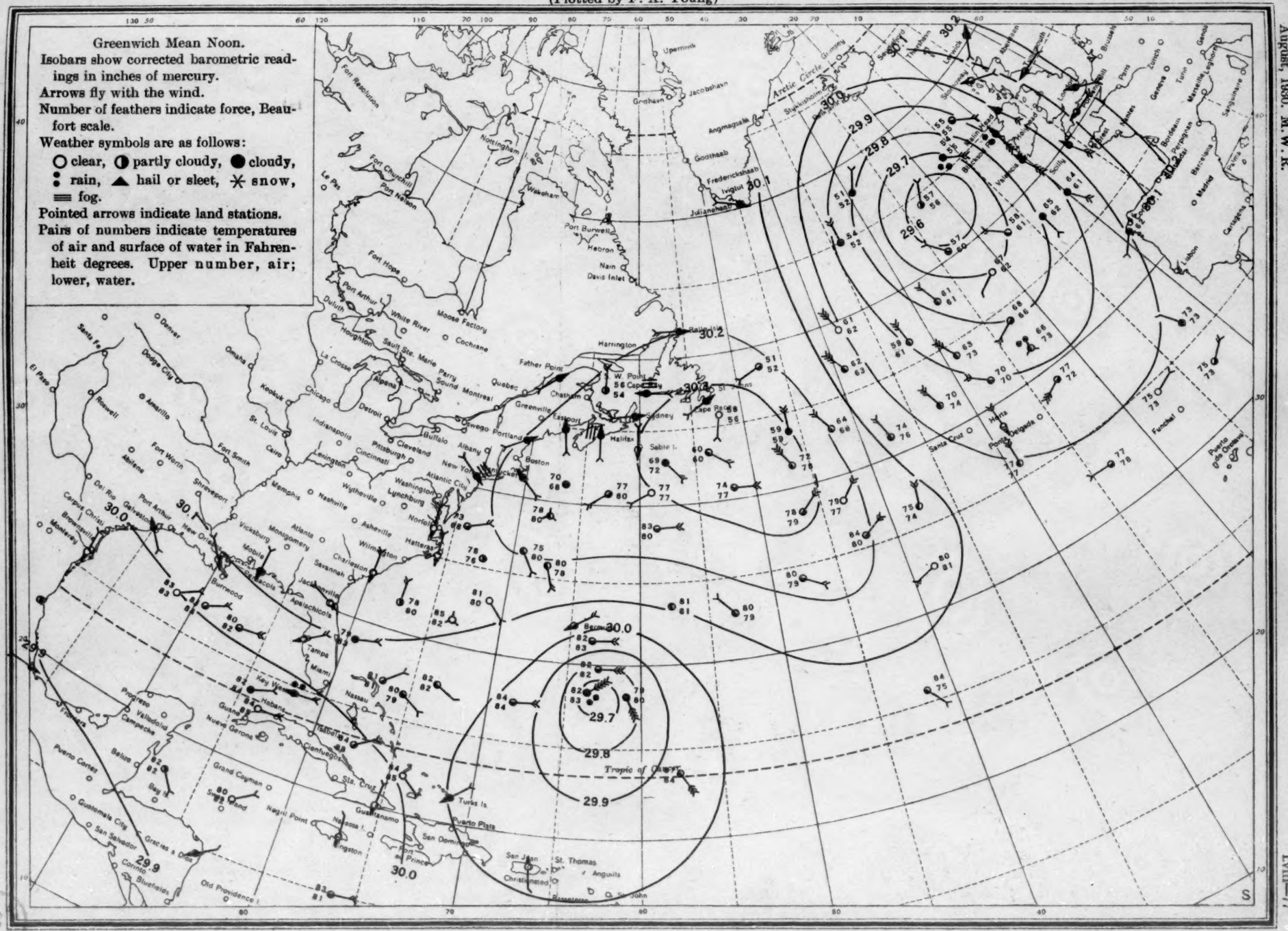


Chart IX. Weather Map of North Atlantic Ocean, August 26, 1930

(Plotted by F. A. Young)

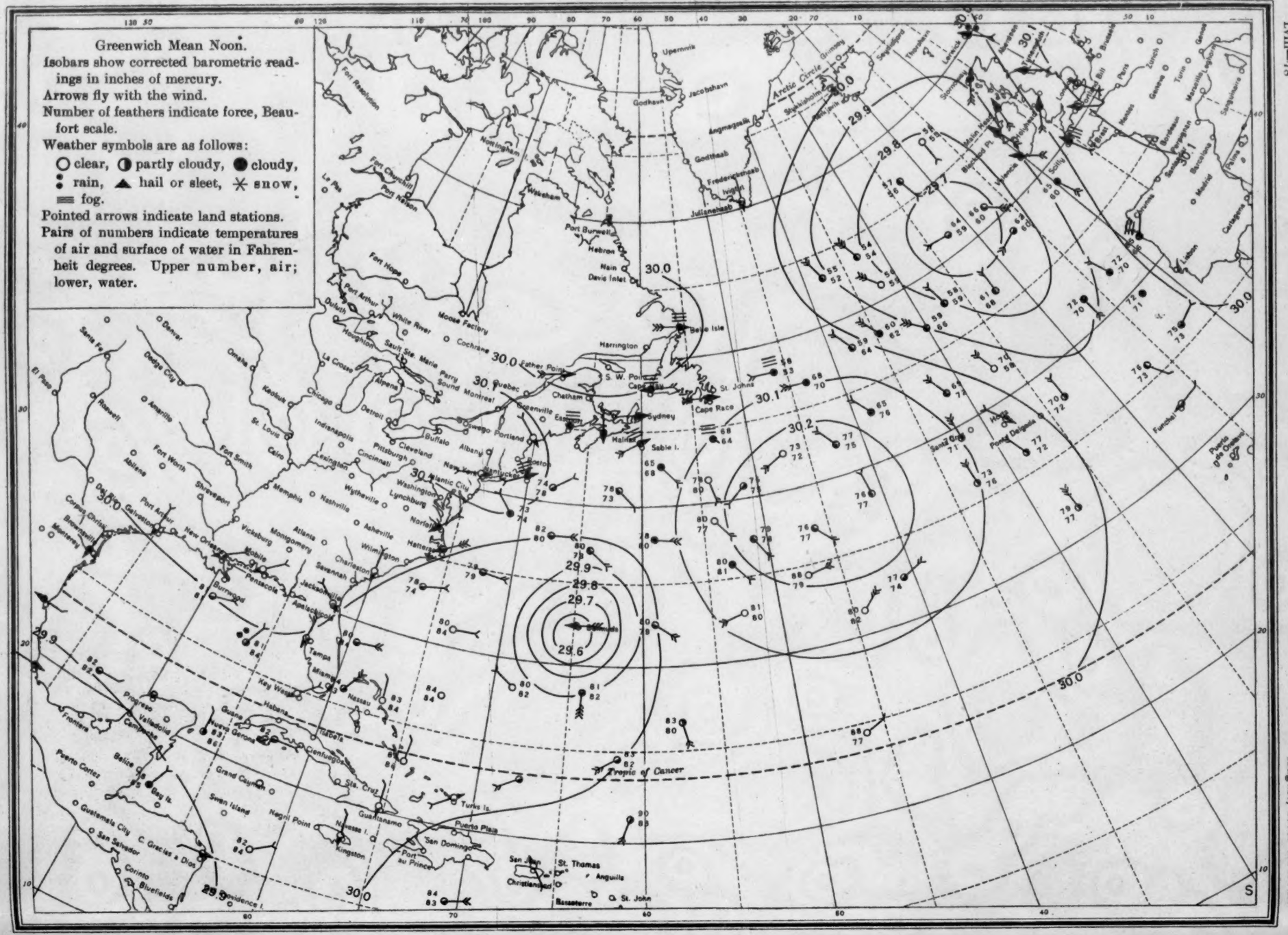


Chart X. Weather Map of North Atlantic Ocean, August 27, 1930

(Plotted by F. A. Young)

Chart X. Weather Map of North Atlantic Ocean, August 27, 1930

(Plotted by F. A. Young)

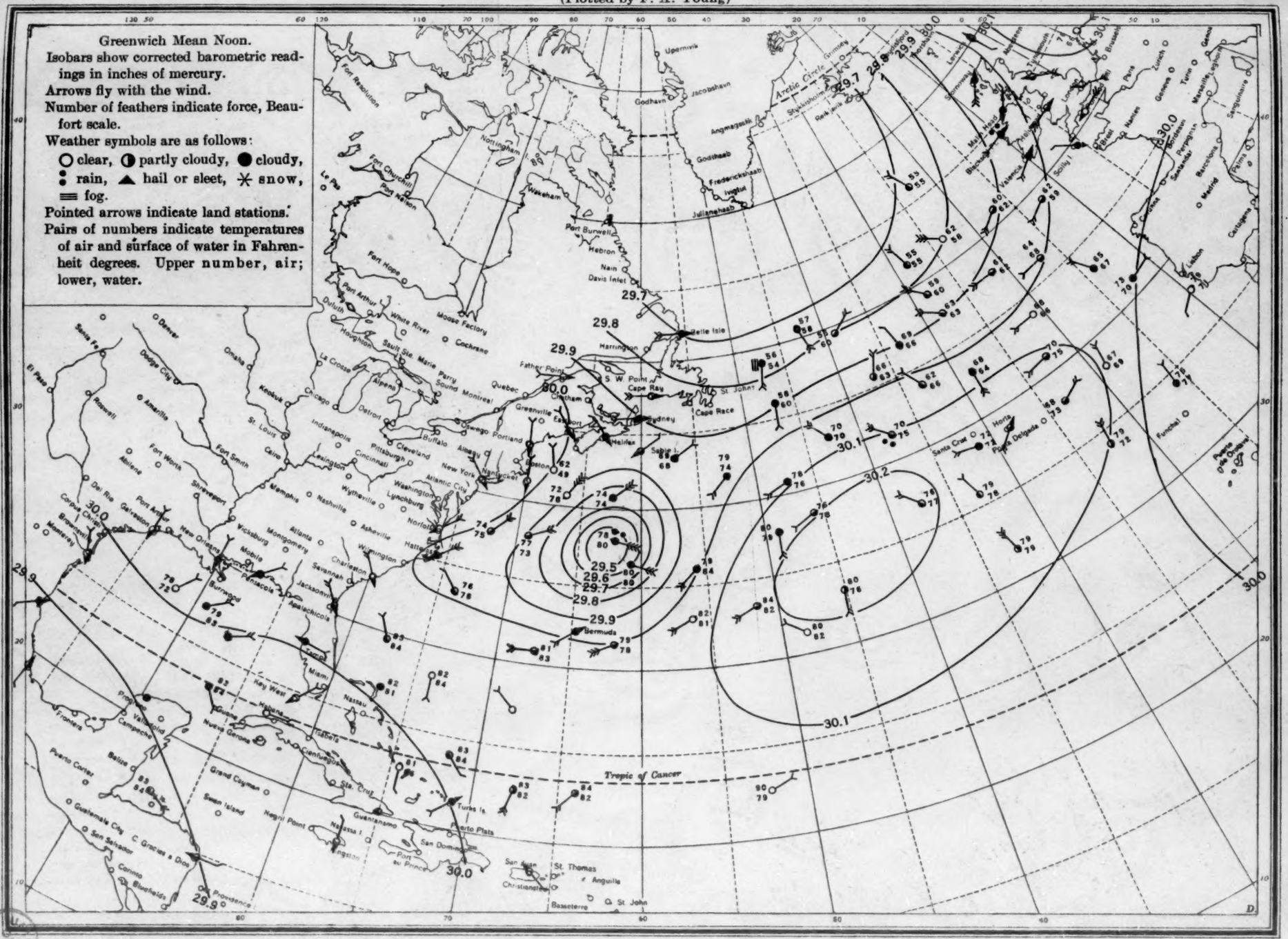


Chart XI. Weather Map of North Atlantic Ocean, August 28, 1930

(Plotted by F. A. Young)

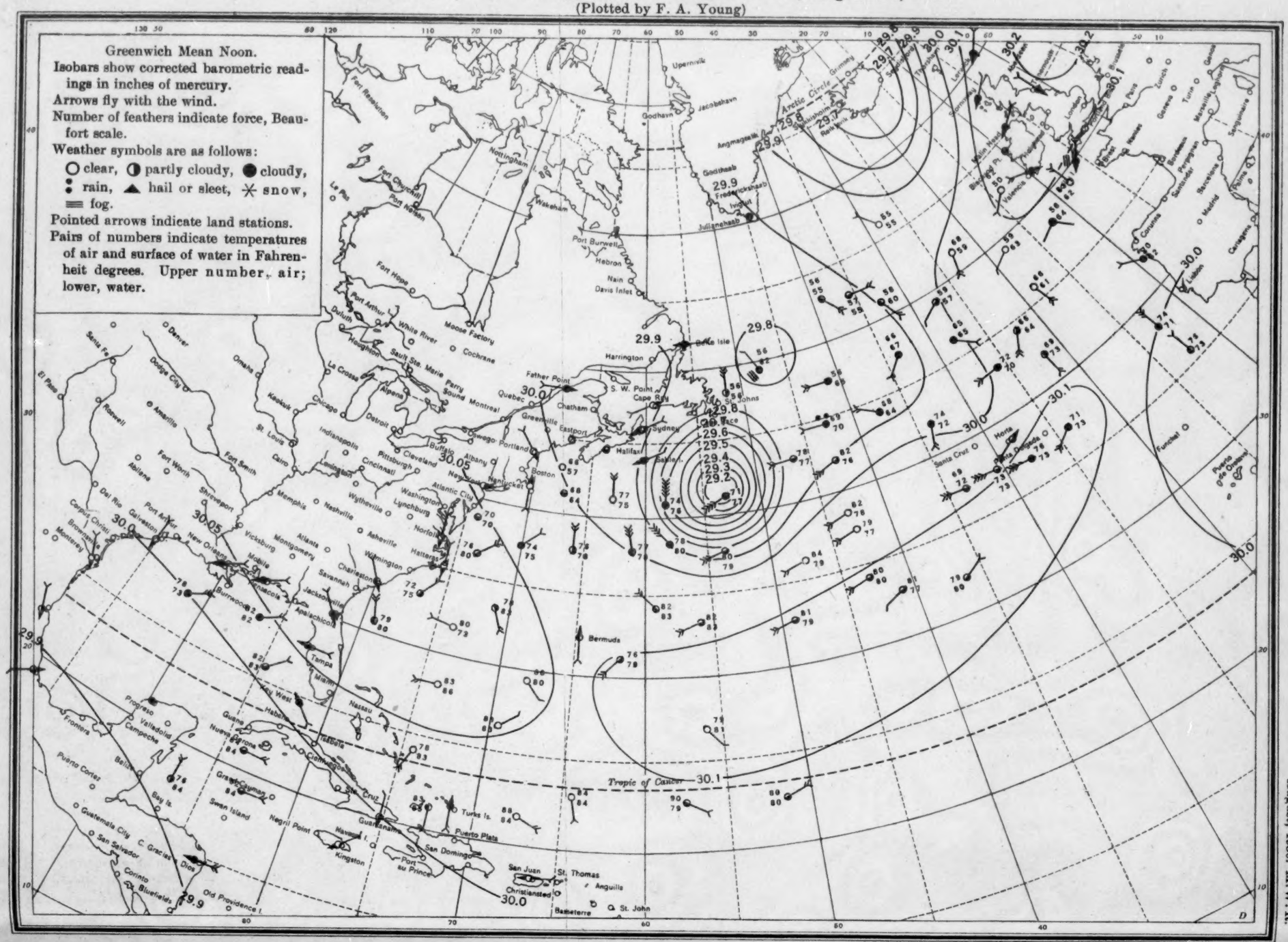


Chart XII. Weather Map of North Atlantic Ocean, August 29, 1930

(Plotted by F. A. Young)

Chart XII. Weather Map of North Atlantic Ocean, August 29, 1930

(Plotted by F. A. Young)

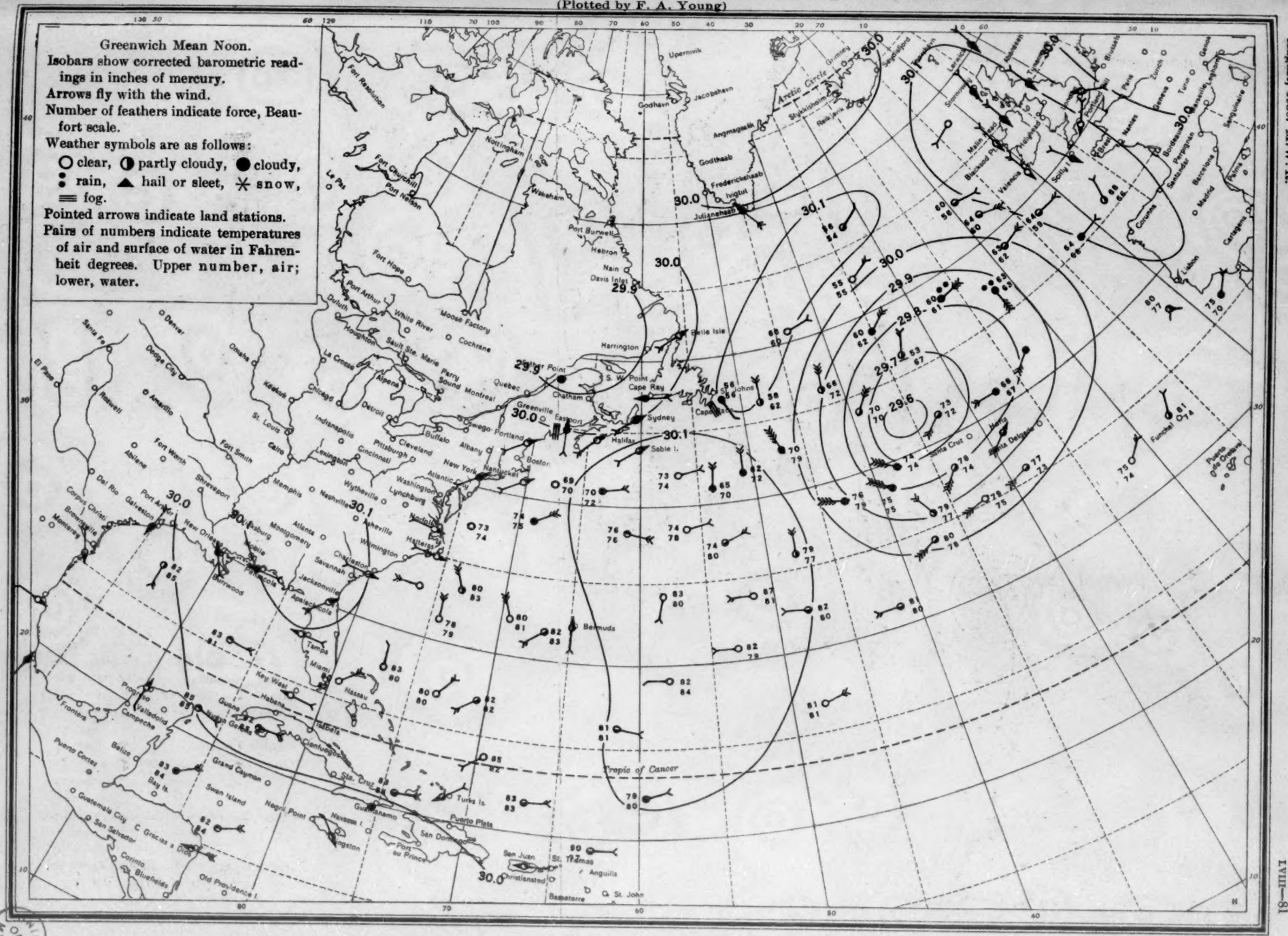
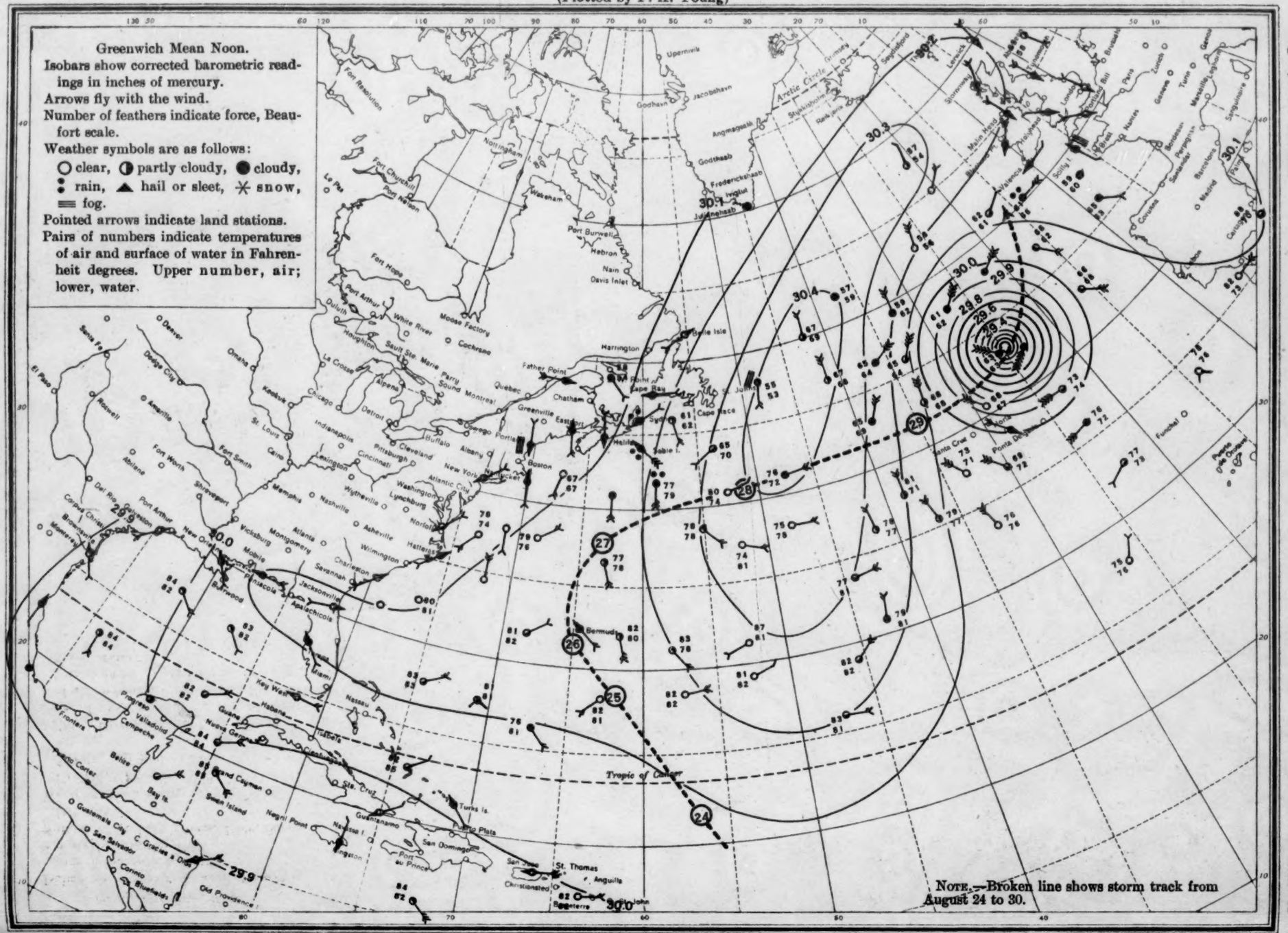

Greenwich Mean Noon.
Isobars show corrected barometric readings in inches of mercury.
Arrows fly with the wind.
Number of feathers indicate force, Beaufort scale.
Weather symbols are as follows:
clear, partly cloudy, cloudy,
rain, hail or sleet, snow,
fog.
Pointed arrows indicate land stations.
Pairs of numbers indicate temperatures of air and surface of water in Fahrenheit degrees. Upper number, air; lower, water.
Arctic Circle
Tropic of Cancer
Godthaab
Julianehaab
Fredericksdal
Ivigtut
Nain
Hebron
Port Burwell
Fort Churchill
Port Nelson
Fort Hope
Moose Factory
Cochrane
White River
Port Arthur
Duluth
Houghton
Sault Ste. Marie
Parry Sound
Montreal
Quebec
Belle Isle
Harrington
Cape Ray
St. John's
Sydney
Halifax
Sable I.
Boston
New York
Nantucket
Portland
Eastport
Chatham
Greenville
Buffalo
Albany
Cleveland
Pittsburgh
Detroit
Chicago
Milwaukee
Duluth
La Crosse
Alpena
Omaha
Kansas City
St. Louis
Cairo
Indianapolis
Cincinnati
Lexington
Wytheville
Lynchburg
Washington
Atlantic City
Memphis
Nashville
Asheville
Hatteras
Wilmington
Charleston
Savannah
Jacksonville
Atlanta
Montgomery
Mobile
New Orleans
Galveston
Port Arthur
Corpus Christi
Brownsville
Monterey
Del Rio
Abilene
Fort Worth
Shreveport
Fort Smith
Amarillo
Dodge City
Denver
Santa Fe
El Paso
Roswell
Bermuda
Hamilton
Nassau
Tampa
Miami
Key West
Havana
Matanzas
Cienfuegos
Sta. Cruz
Guantanamo
Turks Is.
Puerto Plata
San Domingo
Port au Prince
Jamaica
Kingston
Navassa I.
Negril Point
Grand Cayman
Swan Island
Bay Is.
Belize
Puerto Cortez
Guatemala City
San Salvador
C. Gracias a Dios
Bluefields
Old Providence I.
Campeche
Valladolid
Frontera
Progreso
Tuxpan
Tampico
Burrwood
Apalachicola
Pensacola
Mobile
Hatteras
Wilmington
Charleston
Savannah
Jacksonville

Chart XIII. Weather Map of North Atlantic Ocean, August 30, 1930

(Plotted by F. A. Young)



NOTE.—Broken line shows storm track from August 24 to 30.